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Remote Interface Reference

Remote Interface Reference

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For information on the programming commands for the Phase-Lock Option, refer to the User's and Service Guide included with Option 001.

SCPI

If you are a first-time user of the SCPI language, you may want to refer to these sections to become familiar with the language before attempting to program the function generator.

SCPI Command Summary

This section summarizes the SCPI (*Standard Commands for Programmable Instruments*) commands available to program the function generator over the remote interface. Refer to the later sections in this chapter for more complete details on each command.

Throughout this manual, the following conventions are used for SCPI command syntax.

- Square brackets (**[ ]**) indicate optional keywords or parameters.
- Braces (**{ }**) enclose parameters within a command string.
- Triangle brackets (**< >**) indicate that you must substitute a value for the enclosed parameter.
- A vertical bar (**|**) separates multiple parameter choices.

First-time SCPI users, see page 211.

The APPLy Commands

(*see page 138 for more information*)

```
APPLy:SINusoid [<frequency> [,<amplitude> [,<offset>] ]]

APPLy:SQUare [<frequency> [,<amplitude> [,<offset>] ]]

APPLy:TRIangle [<frequency> [,<amplitude> [,<offset>] ]]

APPLy:RAMP [<frequency> [,<amplitude> [,<offset>] ]]

APPLy:NOISe [<frequency|DEFault>[1] [,<amplitude> [,<offset>] ]]

APPLy:DC [<frequency|DEFault>[1] [,<amplitude|DEFault>[1] [,<offset>] ]]

APPLy:USER [<frequency> [,<amplitude> [,<offset>] ]]

APPLy?
```

[1] *This parameter is ignored for this command but you MUST specify a value or "DEFault".*

Output Configuration Commands

(*see page 145 for more information*)

```
[SOURce:]
  FUNCtion:SHAPe {SINusoid|SQUare|TRIangle|RAMP|NOISe|DC|USER}
  FUNCtion:SHAPe?

[SOURce:]
  FREQuency {<frequency>|MINimum|MAXimum}
  FREQuency? [MINimum|MAXimum]

[SOURce:]
  PULSe:DCYCle {<percent>|MINimum|MAXimum}
  PULSe:DCYCle? [MINimum|MAXimum]

[SOURce:]
  VOLTage {<amplitude>|MINimum|MAXimum}
  VOLTage? [MINimum|MAXimum]
  VOLTage:OFFSet {<offset>|MINimum|MAXimum}
  VOLTage:OFFSet? [MINimum|MAXimum]
  VOLTage:UNIT {VPP|VRMS|DBM|DEFault}
  VOLTage:UNIT?

OUTPut:LOAD {50|INFinity|MINimum|MAXimum}
OUTPut:LOAD? [MINimum|MAXimum]

OUTPut:SYNC {OFF|ON}
OUTPut:SYNC?

*SAV {0|1|2|3}        State 0 is the instrument state at power down.
*RCL {0|1|2|3}        States 1, 2, and 3 are user-defined instrument states.

MEMory:STATe:DELete {0|1|2|3}
```

Default parameters are shown in **bold**.

Modulation Commands

(*see page 154 for more information*)

```
[SOURce:]
  AM:DEPTh {<depth in percent>|MINimum|MAXimum}
  AM:DEPTh? [MINimum|MAXimum]
  AM:INTernal:FUNCtion {SINusoid|SQUare|TRIangle|RAMP|NOISe|USER}
  AM:INTernal:FUNCtion?
  AM:INTernal:FREQuency {<frequency>|MINimum|MAXimum}
  AM:INTernal:FREQuency? [MINimum|MAXimum]
  AM:SOURce {BOTH|EXTernal}
  AM:SOURce?
  AM:STATe {OFF|ON}
  AM:STATe?

[SOURce:]
  FM:DEViation {<peak deviation in Hz>|MINimum|MAXimum}
  FM:DEViation? [MINimum|MAXimum]
  FM:INTernal:FUNCtion {SINusoid|SQUare|TRIangle|RAMP|NOISe|USER}
  FM:INTernal:FUNCtion?
  FM:INTernal:FREQuency {<frequency>|MINimum|MAXimum}
  FM:INTernal:FREQuency? [MINimum|MAXimum]
  FM:STATe {OFF|ON}
  FM:STATe?

[SOURce:]
  BM:NCYCles {<# cycles>|INFinity|MINimum|MAXimum}
  BM:NCYCles? [MINimum|MAXimum]
  BM:PHASe {<degrees>|MINimum|MAXimum}
  BM:PHASe? [MINimum|MAXimum]
  BM:INTernal:RATE {<frequency>|MINimum|MAXimum}
  BM:INTernal:RATE? [MINimum|MAXimum]
  BM:SOURce {INTernal|EXTernal}                    Gated Burst Mode
  BM:SOURce?
  BM:STATe {OFF|ON}
  BM:STATe?

TRIGger:SOURce {IMMediate|EXTernal|BUS}      Triggered Burst Mode
TRIGger:SOURce?
```

Default parameters are shown in **bold**.

Frequency-Shift Keying (FSK) Commands

(*see page 167 for more information*)

```
[SOURce:]
  FSKey:FREQuency {<frequency>|MINimum|MAXimum}
  FSKey:FREQuency? [MINimum|MAXimum]
  FSKey:INTernal:RATE {<rate in Hz>|MINimum|MAXimum}
  FSKey:INTernal:RATE? [MINimum|MAXimum]
  FSKey:SOURce {INTernal|EXTernal}
  FSKey:SOURce?
  FSKey:STATe {OFF|ON}
  FSKey:STATe?
```

Sweep Commands

(*see page 170 for more information*)

```
[SOURce:]
  FREQuency:STARt {<frequency>|MINimum|MAXimum}
  FREQuency:STARt? [MINimum|MAXimum]
  FREQuency:STOP {<frequency>|MINimum|MAXimum}
  FREQuency:STOP? [MINimum|MAXimum]

[SOURce:]
  SWEep:SPACing {LINear|LOGarithmic}
  SWEep:SPACing?
  SWEep:TIME {<seconds>|MINimum|MAXimum}
  SWEep:TIME? [MINimum|MAXimum]
  SWEep:STATe {OFF|ON}
  SWEep:STATe?

TRIGger:SOURce {IMMediate|EXTernal|BUS}      Triggered Sweep Mode
TRIGger:SOURce?
```

Default parameters are shown in **bold**.

Arbitrary Waveform Commands

(*see page 174 for more information*)

```
[SOURce:]
  FUNCtion:USER {<arb name>[1]|VOLATILE}
  FUNCtion:USER?
  FUNCtion:SHAPe USER
  FUNCtion:SHAPe?
```

[1] *Specify 1 of the 5 built-in waveforms or a user-defined waveform name.*

```
DATA VOLATILE, <value>,<value>, . . .

DATA:DAC VOLATILE, {<binary block>|<value>,<value>, . . .}

DATA:ATTRibute:AVERage? [<arb name>]
DATA:ATTRibute:CFACtor? [<arb name>]
DATA:ATTRibute:POINts? [<arb name>]
DATA:ATTRibute:PTPeak? [<arb name>]

DATA:CATalog?

DATA:COPY <destination arb name> [,VOLATILE]

DATA:DELete <arb name>
DATA:DELete:ALL

DATA:NVOLatile:CATalog?
DATA:NVOLatile:FREE?

FORMat:BORDer {NORMal|SWAPped}        Specify Byte Order
FORMat:BORDer?
```

Default parameters are shown in **bold**.

Triggering Commands

(*see page 186 for more information*)

```
TRIGger:SOURce {IMMediate|EXTernal|BUS}
TRIGger:SOURce?

TRIGger:SLOPe {POSitive|NEGative}
TRIGger:SLOPe?

*TRG
```

System-Related Commands

(*see page 188 for more information*)

```
DISPlay {OFF|ON}
DISPlay?

DISPlay:TEXT <quoted string>
DISPlay:TEXT?
DISPlay:TEXT:CLEar

SYSTem:BEEPer

SYSTem:ERRor?

SYSTem:VERSion?

*IDN?

*RST

*TST?

*SAV {0|1|2|3}
*RCL {0|1|2|3}
```

State 0 is the instrument state at power down.
States 1, 2, and 3 are user-defined instrument states.

```
MEMory:STATe:DELete {0|1|2|3}
```

Default parameters are shown in **bold**.

Calibration Commands

(*see page 193 for more information*)

```
CALibration?

CALibration:COUNt?

CALibration:SECure:CODE <new code>

CALibration:SECure:STATe {OFF|ON},<code>
CALibration:SECure:STATe?

CALibration:SETup <0|1|2|3| . . . |84>
CALibration:SETup?

CALibration:STRing <quoted string>
CALibration:STRing?

CALibration:VALue <value>
CALibration:VALue?
```

RS-232 Interface Commands

(*see page 200 for more information*)

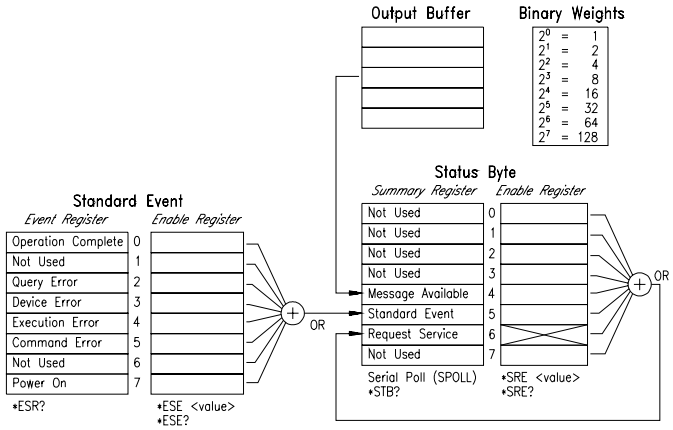
```
SYSTem:LOCal

SYSTem:REMote

SYSTem:RWLock
```

Default parameters are shown in **bold**.

Status Reporting Commands

(*see page 209 for more information*)

```
SYSTem:ERRor?

*CLS

*ESE <enable value>
*ESE?

*ESR?

*OPC

*OPC?

*PSC {0|1}
*PSC?

*SRE <enable value>
*SRE?

*STB?

*WAI
```



Default parameters are shown in **bold**.

IEEE-488.2 Common Commands

(*see page 209 for more information*)

```
*CLS

*ESE <enable value>
*ESE?

*ESR?

*IDN?

*OPC

*OPC?

*PSC {0|1}
*PSC?

*RST

*SAV {0|1|2|3}
*RCL {0|1|2|3}

*SRE <enable value>
*SRE?

*STB?

*TRG

*TST?

*WAI
```

State 0 is the instrument state at power down.
States 1, 2, and 3 are user-defined instrument states.

Default parameters are shown in **bold**.

SCPI

First-time SCPI users, see page 211.

Simplified Programming Overview

This section gives an overview of the basic techniques used to program the function generator over the remote interface. This section is only an overview and does not give all of the details you will need to write your own application programs. Refer to the remainder of this chapter and also chapter 6, "Application Programs", for more details and examples. Also refer to the programming reference manual that came with your computer for details on outputting command strings and entering data.

Using the APPLy Command

The `APPLy` command provides the most straightforward method to program the function generator over the remote interface. For example, the following statement executed from your computer will output a 3 Vpp sine wave at 5 kHz with a -2.5 volt offset:

```
"APPL:SIN 5.0E+3, 3.0, -2.5"
```

Using the Low-Level Commands

Although the `APPLy` command provides the most straightforward method to program the function generator, the low-level commands give you more flexibility to change individual parameters. For example, the following statements executed from your computer will output a 3 Vpp sine wave at 5 kHz with a -2.5 volt offset:

`"FUNC:SHAP SIN"`	*Select sine wave function*
`"FREQ 5.0E+3"`	*Set frequency to 5 kHz*
`"VOLT 3.0"`	*Set amplitude to 3 Vpp*
`"VOLT:OFFS -2.5"`	*Set offset to -2.5 Vdc*

Reading a Query Response

Only the query commands (commands that end with " ? ") will instruct the function generator to send a response message. Queries return either output values or internal instrument settings. For example, the following statements executed from your computer will read the function generator's error queue and print the most recent error:

`dimension statement`	*Dimension string array (80 elements)*
`"SYST:ERR?"`	*Read error queue*
`bus enter statement`	*Enter error string into computer*
`print statement`	*Print error string*

Selecting a Trigger Source

When *burst modulation* or *frequency sweep* is enabled, the function generator will accept an immediate internal trigger, a hardware trigger from the rear-panel *Ext Trig* terminal, or a software (bus) trigger. By default, the internal trigger source is selected. If you want the function generator to use the external source or a bus trigger, you must select that source. For example, the following statements executed from your computer will output a 3-cycle burst each time the *Ext Trig* terminal receives the rising edge of a TTL pulse:

`"BM:NCYC 3"`	*Set burst count to 3 cycles*
`"TRIG:SOUR EXT"`	*Select external trigger source*
`"BM:STAT ON"`	*Enable the burst mode*

Using the APPLy Command

See also "Output Configuration," starting on page 55 in chapter 3.

The APPLy command provides the most straightforward method to program the function generator over the remote interface. You can select the function, frequency, amplitude, and offset all in one command. For example, the following statement outputs a 3 Vpp sine wave at 5 kHz with a -2.5 volt offset using APPLy:

```
"APPL:SIN 5 KHZ, 3.0 VPP, -2.5 V"
```

The syntax statements for the APPLy command are shown on page 143.

Output Frequency

- For the *frequency* parameter of the APPLy command, the output frequency range depends on the function currently selected. You can substitute "MINimum", "MAXimum", or "DEFault" in place of a specific value for the *frequency* parameter. MIN selects the lowest frequency allowed for the selected function. MAX selects the highest frequency allowed. *The default frequency for all functions is 1 kHz.*

Function	Minimum Frequency	Maximum Frequency
Sine	100 μHz	15 MHz
Square	100 μHz	15 MHz
Ramp	100 μHz	100 kHz
Triangle	100 μHz	100 kHz
Built-In Arbs [1]	100 μHz	5 MHz

[1] There are five built-in arbitrary waveforms stored in non-volatile memory: sinc, negative ramp, exponential rise, exponential fall, and cardiac.

- For *arbitrary waveforms* that you create and download to memory, the maximum frequency depends on the number of points specified in the waveform. As shown below, the maximum output frequency decreases as you specify more points in the waveform. The five built-in arbitrary waveforms can be output at a maximum of 5 MHz.

Number of Arb Points	Minimum Frequency	Maximum Frequency
8 to 8,192 (8k)	100 μHz	5 MHz
8,193 to 12,287 (12k)	100 μHz	2.5 MHz
12,288 to 16,000	100 μHz	200 kHz

- *Possible Conflict with Function Change*: The output frequency is automatically adjusted if you select a function whose maximum frequency is *less than* that of the currently active function. For example, if you output a 1 MHz sine wave and then change the function to triangle wave, the function generator will adjust the output to 100 kHz (the upper limit for triangle waves). *From the remote interface, a -221, "Settings conflict" error is generated and the frequency is adjusted.*
- *Possible Conflict with Duty Cycle (square wave only)*: For output frequencies above 5 MHz, the duty cycle is limited to values between 40% and 60% (below 5 MHz, the range is 20% to 80%). The duty cycle is automatically adjusted if you select a frequency that is not valid with the present duty cycle. For example, if you set the duty cycle to 70% and then change the frequency to 8 MHz, the function generator will automatically adjust the duty cycle to 60% (the upper limit for this frequency). *From the remote interface, a -221, "Settings conflict" error is generated and the duty cycle is adjusted.*

Output Amplitude

- For the *amplitude* parameter of the `APPLy` command, the output amplitude range depends on the function currently selected and the output termination. You can substitute "MINimum", "MAXimum", or "DEFault" in place of a specific value for the *amplitude* parameter. MIN selects the smallest amplitude for the selected function (50 mVpp into 50 ohms). MAX selects the largest amplitude (10 Vpp into 50 ohms). *The default amplitude is 100 mVpp (into 50 ohms) for all functions.*

Function	Output Termination	Minimum Amplitude	Maximum Amplitude
Sine	50Ω	50 mVpp	10 Vpp
Square	50Ω	50 mVpp	10 Vpp
Triangle	50Ω	50 mVpp	10 Vpp
Ramp	50Ω	50 mVpp	10 Vpp
Noise	50Ω	50 mVpp	10 Vpp
Built-In Arbs [1]	50Ω	50 mVpp	10 Vpp
Sine	Open Circuit	100 mVpp	20 Vpp
Square	Open Circuit	100 mVpp	20 Vpp
Triangle	Open Circuit	100 mVpp	20 Vpp
Ramp	Open Circuit	100 mVpp	20 Vpp
Noise	Open Circuit	100 mVpp	20 Vpp
Built-In Arbs [1]	Open Circuit	100 mVpp	20 Vpp

[1] There are five built-in arbitrary waveforms stored in non-volatile memory: sinc, negative ramp, exponential rise, exponential fall, and cardiac.

- For *arbitrary waveforms*, the maximum amplitude will be limited if the data points do not span the full range of the output DAC (Digital-to-Analog Converter). For example, the built-in "SINC" waveform does not use the full range of values between ±1 and therefore its maximum amplitude is 6.084 Vpp (into 50 ohms).
- You can set the units for output amplitude to Vpp, Vrms, or dBm. *See "Output Units" on page 64 for more information.*

- *Possible Conflict with Function Change*: The output amplitude is automatically adjusted if you select a function whose maximum amplitude is *less than* that of the currently active function. This conflict may arise when the output units are *Vrms* or *dBm* due to the differences in crest factor for the output functions. For example, if you output a 5 Vrms square wave (into 50 ohms) and then change the function to sine wave, the function generator will adjust the output amplitude to 3.535 Vrms (the upper limit for sine waves in Vrms). *From the remote interface, a -221, "Settings conflict" error is generated and the amplitude is adjusted.*
- *Output Amplitude and Output Termination*: The output amplitude is automatically adjusted (and no error is generated) if you change the output termination. For example, if you set the amplitude to 10 Vpp and then change the termination from 50 ohms to "high impedance", the displayed amplitude will *double* to 20 Vpp. If you change from "high impedance" to 50 ohms, the displayed amplitude will drop in half. *See "Output Termination" on page 65 for more information.*
- A momentary glitch occurs in the output waveform at certain voltages due to output attenuator switching. This positive-going glitch occurs when the output voltage crosses the break-point voltage either from a lower voltage or a higher voltage. The voltages are shown below (for a 0 volt dc offset):

  ```
  252 mVpp, 399 mVpp, 502 mVpp, 796 mVpp, 1 Vpp, 1.59 Vpp,
  2.0 Vpp, 3.17 Vpp, 3.99 Vpp, 6.32 Vpp, 7.96 Vpp
  ```

- The output voltage will momentarily drop to 0 volts at certain voltages due to output relay switching. This occurs when the output voltage crosses the break-point voltage either from a lower voltage or a higher voltage. The voltages are shown below (for a 0 volt dc offset):

  ```
  317 mVpp, 632 mVpp, 1.26 Vpp, 2.52 Vpp, 5.02 Vpp
  ```

DC Offset Voltage

- For the *offset* parameter of the `APPLy` command, you can substitute "MINimum", "MAXimum", or "DEFault" in place of a specific value for the parameter. MIN selects the smallest dc offset voltage for the selected function (0 volts). MAX selects the largest offset for the selected function. *The default offset voltage is 0 volts for all functions.*
- You can set the offset to a positive or negative number with the restrictions shown below. If the specified offset voltage is not valid, the function generator will automatically adjust it to the maximum dc voltage allowed with the present amplitude. (V*max* is the maximum peak-to-peak amplitude for the selected output termination; V*pp* is the output amplitude in volts peak-to-peak.) *From the remote interface, a -221, "Settings conflict" error is generated and the offset is adjusted.*

$$|V_{offset}| + \frac{V_{pp}}{2} \leq V_{max} \quad and \quad |V_{offset}| \leq 2 \times V_{pp}$$

- *DC Offset and Output Termination*: The offset voltage is automatically adjusted (and no error is generated) if you change the output termination. For example, if you set the offset to 100 mVdc and then change the termination from 50 ohms to "high impedance", the displayed offset will *double* to 200 mVdc. If you change from "high impedance" to 50 ohms, the displayed offset will drop in half. *See "Output Termination" on page 65 for more information.*
- For *arbitrary waveforms*, the **Offset** annunciator will turn on if the waveform data has an inherent offset present (if the average is not equal to zero). The function generator calculates the average of the data points and compares the average to zero volts. If the average is not within two DAC (Digital-to-Analog Converter) counts of zero volts, the **Offset** annunciator turns on.
- For *dc volts*, the output level is actually controlled by setting the offset voltage. You can set the dc voltage to any value between ±5 Vdc into 50 ohms or ±10 Vdc into an open circuit.

APPLy Command Syntax

- Because of the use of optional parameters in the APPLy commands (enclosed in square brackets), you must specify *frequency* to use the *amplitude* parameter, and you must specify both *frequency* and *amplitude* to use the *offset* parameter. The following statement is valid (*frequency* and *amplitude* are specified; *offset* is omitted):

  ```
  "APPL:SIN 5.0E+3, 3.0"
  ```

  However, you CANNOT specify *amplitude* and *offset* without *frequency*.

- You can substitute "MINimum", "MAXimum", or "DEFault" in place of specific values for the *frequency*, *amplitude*, and *offset* parameters. For example, the following statement outputs a 3 Vpp sine wave at 15 MHz (the maximum frequency for sine) with a -2.5 volt offset:

  ```
  "APPL:SIN MAX, 3.0, -2.5"
  ```

APPLy:SINusoid [<*frequency*>** [,**<*amplitude*>** [,**<*offset*>**]]]**
Output a sine wave with the specified frequency, amplitude, and dc offset. The waveform is output as soon as the command is executed.

APPLy:SQUare [<*frequency*>** [,**<*amplitude*>** [,**<*offset*>**]]]**
Output a square wave with the specified frequency, amplitude, and dc offset. The waveform is output as soon as the command is executed.

APPLy:TRIangle [<*frequency*>** [,**<*amplitude*>** [,**<*offset*>**]]]**
Output a triangle wave with the specified frequency, amplitude, and dc offset. The waveform is output as soon as the command is executed.

APPLy:RAMP [<*frequency*>** [,**<*amplitude*>** [,**<*offset*>**]]]**
Output a ramp wave with the specified frequency, amplitude, and dc offset. The waveform is output as soon as the command is executed.

APPLy:NOISe [<*frequency*|DEFault> [,<*amplitude*> [,<*offset*>]]]
Output noise with the specified amplitude and dc offset. The waveform is output as soon as the command is executed.

- The *frequency* parameter is ignored for this command but you MUST specify a value or "DEF". If you specify a frequency, the value is remembered when you change to a different function. For example:

```
"APPL:NOIS DEF, 5.0, 2.0"
```

APPLy:DC [<*frequency*|DEFault> [,<*amplitude*|DEFault> [,<*offset*>]]]
Output a dc voltage with the level specified by the *offset* parameter. The dc voltage is output as soon as the command is executed.

- The *frequency* and *amplitude* parameters are ignored for this command but you MUST specify a value or "DEF". If you specify a frequency and amplitude, the values are remembered when you change to a different function. For example:

```
"APPL:DC DEF, DEF, -2.5"
```

APPLy:USER [<*frequency*> [,<*amplitude*> [,<*offset*>]]]
Output the arbitrary waveform currently selected by the FUNC:USER command. The waveform is output using the specified frequency, amplitude, and dc offset. The waveform is output as soon as the command is executed.

See "Arbitrary Waveform Commands" on page 174 for more information on downloading arbitrary waveforms to memory.

APPLy?
Query the function generator's present configuration and return a quoted string. The function, frequency, amplitude, and offset voltage are returned as shown in the sample string below (the quotation marks are returned as part of the string).

```
"SIN +5.000000000000E+03,+3.000000E+00,-2.500000E+00"
```

Output Configuration Commands

See also "Output Configuration," starting on page 55 in chapter 3.

This section describes the low-level commands used to program the function generator. Although the APPLy command provides the most straightforward method to program the function generator, the low-level commands give you more flexibility to change individual parameters.

FUNCtion:SHAPe {SINusoid|SQUare|TRIangle|RAMP|NOISe|DC|USER}
Select the output function. The selected waveform is output using the previously selected frequency, amplitude, and dc offset settings. If you select "USER", the function generator outputs the arbitrary waveform currently selected by the FUNC:USER command. *The default is SIN.*
[*Stored in volatile memory*]

- The following matrix shows which output functions are allowed with each modulation mode. Each "X" indicates a valid combination. If you change to a function that is not allowed with the selected modulation, the modulation mode is turned off.

	Sine	Square	Triangle	Ramp	Noise	Arb
AM Carrier	X	X	X	X		X
AM Modulating Wave	X	X	X	X	X	X
FM Carrier	X	X	X	X		X
FM Modulating Wave	X	X	X	X	X	X
FSK Modulation	X	X	X	X		X
Burst Modulation	X	X	X	X		X
Frequency Sweep	X	X	X	X		X

FUNCtion:SHAPe?
Query the output function. Returns "SIN", "SQU", "TRI", "RAMP", "NOIS", "DC", or "USER".

FREQuency {<*frequency*>|MINimum|MAXimum}
Set the output frequency. MIN selects the lowest frequency allowed for the currently active function. MAX selects the highest frequency allowed for the currently active function. *The default frequency is 1 kHz for all functions*. [*Stored in volatile memory*]

Function	Minimum Frequency	Maximum Frequency
Sine	100 μHz	15 MHz
Square	100 μHz	15 MHz
Ramp	100 μHz	100 kHz
Triangle	100 μHz	100 kHz
Built-In Arbs [1]	100 μHz	5 MHz

[1] There are five built-in arbitrary waveforms stored in non-volatile memory: sinc, negative ramp, exponential rise, exponential fall, and cardiac.

- For *arbitrary waveforms* that you create and download to memory, the maximum frequency depends on the number of points specified in the waveform. As shown below, the maximum output frequency decreases as you specify more points in the waveform. The five built-in arbitrary waveforms can be output at a maximum of 5 MHz.

Number of Arb Points	Minimum Frequency	Maximum Frequency
8 to 8,192 (8k)	100 μHz	5 MHz
8,193 to 12,287 (12k)	100 μHz	2.5 MHz
12,288 to 16,000	100 μHz	200 kHz

- *Possible Conflict with Function Change*: The output frequency is automatically adjusted if you select a function whose maximum frequency is *less than* that of the currently active function. For example, if you output a 1 MHz sine wave and then change the function to triangle wave, the function generator will adjust the output to 100 kHz (the upper limit for triangle waves). *From the remote interface, a -221, "Settings conflict" error is generated and the frequency is adjusted.*

FREQuency? [MINimum|MAXimum]
Query the frequency setting for the function currently active. Returns a value in hertz.

PULSe:DCYCle {<*percent*>|MINimum|MAXimum}
Set the duty cycle in percent for *square waves only*. Duty cycle represents the amount of time per cycle that the square wave is high. *The default is 50%.* [*Stored in volatile memory*]

- Duty cycle: 20% to 80%, in 1% increments (*frequency* ≤ 5 MHz).
  40% to 60%, in 1% increments (*frequency* > 5 MHz).
  The default is 50%.
- The duty cycle setting is remembered when you change from square wave to another function. When you return to the square wave function, the previous duty cycle is used. The APPLy command automatically sets the duty cycle to 50% for square waves.
- *Possible Conflict with Output Frequency*: The duty cycle is automatically adjusted if you select a frequency that is not valid with the present duty cycle. For example, if you set the duty cycle to 70% and then change the frequency to 8 MHz, the function generator will automatically adjust the duty cycle to 60% (the upper limit for this frequency). *From the remote interface, a -221, "Settings conflict" error is generated and the duty cycle is adjusted.*

PULSe:DCYCle? [MINimum|MAXimum]
Query the duty cycle setting. Returns a value in percent.

`VOLTage {<`*amplitude***`>|MINimum|MAXimum}`**
Set the output amplitude for the currently active function. MIN selects the smallest amplitude allowed for the selected function (50 mVpp into 50 ohms). MAX selects the largest amplitude allowed (10 Vpp into 50 ohms). *The default amplitude is 100 mVpp (into 50 ohms).*
[*Stored in volatile memory*]

Function	Output Termination	Minimum Amplitude	Maximum Amplitude
Sine	50Ω	50 mVpp	10 Vpp
Square	50Ω	50 mVpp	10 Vpp
Triangle	50Ω	50 mVpp	10 Vpp
Ramp	50Ω	50 mVpp	10 Vpp
Noise	50Ω	50 mVpp	10 Vpp
Built-In Arbs [1]	50Ω	50 mVpp	10 Vpp
Sine	Open Circuit	100 mVpp	20 Vpp
Square	Open Circuit	100 mVpp	20 Vpp
Triangle	Open Circuit	100 mVpp	20 Vpp
Ramp	Open Circuit	100 mVpp	20 Vpp
Noise	Open Circuit	100 mVpp	20 Vpp
Built-In Arbs [1]	Open Circuit	100 mVpp	20 Vpp

[1] There are five built-in arbitrary waveforms stored in non-volatile memory: sinc, negative ramp, exponential rise, exponential fall, and cardiac.

- For *arbitrary waveforms*, the maximum amplitude will be limited if the data points do not span the full range of the output DAC (Digital-to-Analog Converter). For example, the built-in "SINC" waveform does not use the full range of values between ±1 and therefore its maximum amplitude is 6.084 Vpp (into 50 ohms).
- You can set the units for output amplitude to Vpp, Vrms, or dBm. *See the* `VOLT:UNIT` *command for more information.*
- For *dc volts*, the output level is actually controlled by setting the offset voltage. You can set the dc voltage to any value between ±5 Vdc into 50 ohms or ±10 Vdc into an open circuit. *See the* `VOLT:OFFS` *command for more information.*

- *Possible Conflict with Function Change*: The output amplitude is automatically adjusted if you select a function whose maximum amplitude is *less than* that of the currently active function. This conflict may arise when the output units are *Vrms* or *dBm* due to the differences in crest factor for the output functions. For example, if you output a 5 Vrms square wave (into 50 ohms) and then change the function to sine wave, the function generator will adjust the output amplitude to 3.535 Vrms (the upper limit for sine waves in Vrms). *From the remote interface, a -221, "Settings conflict" error is generated and the amplitude is adjusted.*
- *Output Amplitude and Output Termination*: The output amplitude is automatically adjusted (and no error is generated) if you change the output termination. For example, if you set the amplitude to 10 Vpp and then change the termination from 50 ohms to "high impedance", the displayed amplitude will *double* to 20 Vpp. If you change from "high impedance" to 50 ohms, the displayed amplitude will drop in half. *See the* `OUTP:LOAD` *command for more information.*

`VOLTage? [MINimum|MAXimum]`
Query the output amplitude for the currently selected function. Returns the magnitude of the output amplitude. Units are not returned but are in the units set by the most recent `VOLT:UNIT` command.

`VOLTage:OFFSet {<`*offset*`>|MINimum|MAXimum}`
Set the dc offset voltage for the currently active function. MIN selects the smallest dc offset voltage for the selected function (0 volts). MAX selects the largest offset for the selected function. *The default offset voltage is 0 volts for all functions.* [*Stored in volatile memory*]

- You can set the offset to a positive or negative number with the restrictions shown below. If the specified offset voltage is not valid, the function generator will automatically adjust it to the maximum dc voltage allowed with the present amplitude. (V*max* is the maximum peak-to-peak amplitude for the selected output termination; V*pp* is the output amplitude in volts peak-to-peak.) *From the remote interface, a -221, "Settings conflict" error is generated and the offset is adjusted.*

$$|V_{offset}| + \frac{V_{pp}}{2} \leq V_{max} \quad and \quad |V_{offset}| \leq 2 \times V_{pp}$$

VOLTage:OFFSet *(continued)*

- *DC Offset and Output Termination*: The offset voltage is automatically adjusted (and no error is generated) if you change the output termination. For example, if you set the offset to 100 mVdc and then change the termination from 50 ohms to "high impedance", the displayed offset will *double* to 200 mVdc. If you change from "high impedance" to 50 ohms, the displayed offset will drop in half. *See the* `OUTP:LOAD` *command for more information.*
- For *dc volts*, the output level is actually controlled by setting the offset voltage. You can set the dc voltage to any value between ±5 Vdc into 50 ohms or ±10 Vdc into an open circuit.
- For *arbitrary waveforms*, the **Offset** annunciator will turn on if the waveform data has an inherent offset present (if the average is not equal to zero). The function generator calculates the average of the data points and compares the average to zero volts. If the average is not within two DAC (Digital-to-Analog Converter) counts of zero volts, the **Offset** annunciator turns on.

`VOLTage:OFFSet? [MINimum|MAXimum]`
Query the dc offset voltage for the currently selected function. Returns a value in dc volts.

`VOLTage:UNIT {VPP|VRMS|DBM|DEFault}`
Select the output units for *amplitude only* (*does not affect offset*). When switching from remote programming over the interface back to front-panel (local) operation, the output units are remembered. For example, if you select "Vrms" from the remote interface, the units are shown as "Vrms" on the front-panel display. *The default is VPP.*
[*Stored in volatile memory*]

`VOLTage:UNIT?`
Query the units selected. Returns "VPP", "VRMS", or "DBM".

OUTPut:LOAD {50|INFinity|MINimum|MAXimum}
Select the output termination for output amplitude and offset voltage. The function generator has a fixed output impedance of 50 ohms on the *OUTPUT* terminal. You can specify whether **you** are terminating the output into a 50 ohm load or an open circuit. Incorrect impedance matching between the function generator and your load will result in an amplitude or offset which does not match the specified signal level.
[*Stored in volatile memory*]

- INF sets the output termination to "high impedance". MIN selects 50Ω. MAX selects "high impedance". *The default is "50".*
- The amplitude (or dc offset) is automatically adjusted (and no error is generated) if you change the output termination. For example, if you set the amplitude to 10 Vpp and then change the termination from 50 ohms to "high impedance", the displayed amplitude will *double* to 20 Vpp. If you change from "high impedance" to 50 ohms, the displayed amplitude will drop in half.
- If you specify a 50 ohm termination but are actually terminating into an open circuit, the displayed output will be *twice* the value specified. For example, if you set the offset to 100 mVdc (and specify a 50 ohm termination) but are actually terminating the output into an open circuit, the actual displayed offset will be 200 mVdc.

OUTPut:LOAD? [MINimum|MAXimum]
Query the output impedance. Returns "50" or "9.9E+37".

OUTPut:SYNC {OFF|ON}
Disable or enable output from the *SYNC* terminal. *The default is "ON".* When the sync signal is disabled, the output level on the *SYNC* terminal is indeterminate (it might be a TTL "high" or a TTL "low").
[*Stored in volatile memory*]

See "SYNC Signal" on page 68 in chapter 3 for more information on the SYNC signal provided for each of the output functions.

OUTPut:SYNC?
Query the state of the *SYNC* terminal. Returns "0" (OFF) or "1" (ON).

***SAV {0|1|2|3}**
Store up to four different instrument configurations.
[*Stored in non-volatile memory*]

- Four memory locations (numbered 0, 1, 2, and 3) are available to store instrument configurations. The state storage feature "remembers" the function (including arbitrary waveforms), frequency, amplitude, dc offset, duty cycle, as well as any modulation parameters. To recall a stored state, you must use the same memory location used previously to store the state.
- From the remote interface only, you can use memory location "0" to store a fourth instrument configuration (you cannot store to this memory location from the front panel). However, keep in mind that memory location "0" is automatically overwritten when the power is turned off.
- Any arbitrary waveforms downloaded to "VOLATILE" memory *are not* remembered. However, if an arbitrary waveform is being output from *non-volatile* memory when the state is stored, the waveform data is stored. The stored waveform is output when the instrument state is recalled.
- If you delete an arbitrary waveform after storing the state, the waveform data is lost and the function generator will not output the waveform when the state is recalled. The "SINC" waveform is output in place of the deleted waveform.
- When power is turned off, the function generator automatically stores its state in memory location "0". You can configure the function generator to automatically recall the power-down state when power is restored. The recall mode is *disabled* when the function generator is shipped from the factory.

  Select the POWER ON LAST STATE command from the SYS MENU to enable the power-down recall mode. Select POWER ON DEFAULT to disable the power-down recall mode. *See "Power-Down Recall Mode" on page 109 for more information.*

`*RCL {0|1|2|3}`
Recall a previously stored state. To recall a stored state, you must use the same memory location used previously to store the state.

- You cannot recall the instrument state from a memory location that was not previously specified as a storage location. For example, an error is generated if you attempt to recall from memory location "2" but have never stored to that location. *From the remote interface, a +810, "State has not been stored" error is generated if nothing is stored in the specified memory location.*

`MEMory:STATe:DELete {0|1|2|3}`
Delete a previously stored state and clear the memory location.
If nothing is stored in the specified memory location, a *+810, "State has not been stored"* error is generated.

AM Modulation Commands

See also "Amplitude Modulation," starting on page 71 in chapter 3.

AM Overview

The following is an overview of the steps required to generate an AM waveform. The commands used for AM are listed on the next page.

1 Set up the carrier waveform.

Use the `APPLy` command or the equivalent `FUNC:SHAP`, `FREQ`, `VOLT`, and `VOLT:OFFS` commands to select the function, frequency, amplitude, and offset of the carrier waveform. You can select a sine, square, triangle, ramp, or arbitrary waveform for the carrier.

2 Select the shape of the modulating waveform.

You can modulate the carrier with a sine, square, triangle, ramp, noise, or arbitrary waveform. Use the `AM:INT:FUNC` command to select the modulating waveshape.

3 Set the modulating frequency.

Set the modulating frequency to any value between 10 mHz and 20 kHz using the `AM:INT:FREQ` command.

4 Set the modulation depth.

Set the modulation depth to a value between 0% and 120% using the `AM:DEPT` command.

5 Select the modulation source.

The function generator will accept an internal modulating signal, an external modulating signal, or both. Select the modulating source using the `AM:SOUR` command.

6 Enable AM modulation.

After you have set up the other modulation parameters, use the `AM:STAT ON` command to enable AM.

AM Commands

> *Use the* APPLy *command or the equivalent* FUNC:SHAP, FREQ, VOLT, *and* VOLT:OFFS *commands to configure the carrier waveform. Set the carrier frequency between* 100 μHz *and* 15 MHz *(100 kHz for triangle and ramp). The default is 1 kHz.*

AM:DEPTh {<*depth in percent***>|MINimum|MAXimum}**
Set the internal modulation depth in percent. Select from 0% to 120%. *The default is 100%*. MIN = 0%. MAX = 120%. [*Stored in volatile memory*]

If you select the *external* modulating source (AM:SOUR EXT), the modulation depth is controlled by the signal level present on the *AM Modulation* terminal (5 volts **peak** corresponds to 100% modulation).

AM:DEPTh? [MINimum|MAXimum]
Query the modulation depth. Returns a value in percent.

AM:INTernal:FUNCtion {SINusoid|SQUare|TRIangle|RAMP|NOISe|USER}
Select the shape of the *modulating* waveform. Used only when the *internal* modulation source is selected (AM:SOUR INT). You can use the noise function as the modulating waveform. However, you *cannot* use the noise function or dc volts as the carrier waveform. *The default is SIN*. [*Stored in volatile memory*]

AM:INTernal:FUNCtion?
Query the shape of the internal modulating waveform. Returns “SIN”, “SQU”, “TRI”, “RAMP”, “NOIS”, or “USER”.

AM:INTernal:FREQuency {<*frequency***>|MINimum|MAXimum}**
Set the frequency of the *modulating* waveform. Used only when the *internal* modulation source is selected (AM:SOUR INT). Select from 10 mHz to 20 kHz. *The default is 100 Hz*. MIN = 10 mHz. MAX = 20 kHz. [*Stored in volatile memory*]

AM:INTernal:FREQuency? [MINimum|MAXimum]
Query the internal modulating frequency. Returns a value in hertz.

AM:SOURce {BOTH|EXTernal}
Select the source of the modulating signal. The function generator will accept an internal modulating signal, an external modulating signal, or both. *The default is BOTH*. [*Stored in volatile memory*]

- ***The External modulating source is always enabled.***
- When both sources are enabled (*internal-external*), the function generator adds the internal and external modulating signals (the carrier waveform is actually modulated with two waveforms).
- When the internal source is disabled (*external only*), the carrier waveform is modulated with the external waveform. The **Ext** annunciator turns on to indicate that the function generator is expecting a modulating signal on the rear-panel *AM Modulation* terminal.
- You apply the external modulating waveform to the *AM Modulation* terminal. The *modulation depth* is controlled by the signal level present (5 volts **peak** corresponds to 100% modulation).

AM:SOURce?
Query the modulating source. Returns "BOTH" or "EXT".

AM:STATe {OFF|ON}
Disable or enable AM. To ensure proper operation, you should enable AM *after* you have set up the other modulation parameters. Only one modulation mode can be enabled at a time. When you enable AM, the previous modulation mode is turned off.

AM:STATe?
Query the state of AM. Returns "0" (OFF) or "1" (ON).

FM Modulation Commands

See also "Frequency Modulation," starting on page 76 in chapter 3.

FM Overview

The following is an overview of the steps required to generate an FM waveform. The commands used for FM are listed on the next page.

1 Set up the carrier waveform.

Use the `APPLy` command or the equivalent `FUNC:SHAP`, `FREQ`, `VOLT`, and `VOLT:OFFS` commands to select the function, frequency, amplitude, and offset of the carrier waveform. You can select a sine, square, triangle, ramp, or arbitrary waveform for the carrier.

2 Select the shape of the modulating waveform.

You can modulate the carrier with a sine, square, triangle, ramp, noise, or arbitrary waveform. Use the `FM:INT:FUNC` command to select the modulating waveshape.

3 Set the modulating frequency.

Set the modulating frequency to any value between 10 mHz and 10 kHz using the `FM:INT:FREQ` command.

4 Set the peak frequency deviation.

Set the deviation to a value between 10 mHz and 7.5 MHz using the `FM:DEV` command.

5 Enable FM modulation.

After you have set up the other modulation parameters, use the `FM:STAT ON` command to enable FM.

FM Commands

> *Use the* APPLy *command or the equivalent* FUNC:SHAP, FREQ, VOLT, *and* VOLT:OFFS *commands to configure the carrier waveform. Set the carrier frequency between 10 mHz and 15 MHz (100 kHz for triangle and ramp). The default is 1 kHz.*

FM:DEViation {<*peak deviation in Hz***>|MINimum|MAXimum}**
Set the peak frequency deviation in hertz. This value represents the variation in frequency of the modulating waveform from the carrier frequency. Select from 10 mHz to 7.5 MHz. *The default is 100 Hz*. MIN = 10 mHz. MAX = 7.5 MHz. [*Stored in volatile memory*]

- The *carrier frequency* must always be greater than or equal to the peak frequency deviation. If you attempt to set the deviation to a value greater than the carrier frequency (with FM enabled), the function generator will automatically adjust the deviation to equal the present carrier frequency. *From the remote interface, a -221, "Settings conflict" error is generated and the deviation is adjusted.*
- The sum of the *carrier frequency* and peak frequency deviation must be less than or equal to the maximum frequency for the selected function ***plus 100 kHz*** (15.1 MHz for sine and square, 200 kHz for triangle and ramp, and 5.1 MHz for arbitrary waveforms). If you attempt to set the deviation to a value that is not valid, the function generator will automatically adjust the deviation to the maximum value allowed with the present carrier frequency. *From the remote interface, a -221, "Settings conflict" error is generated and the deviation is adjusted.*

FM:DEViation? [MINimum|MAXimum]
Query the peak frequency deviation. Returns a value in hertz.

FM:INTernal:FUNCtion {SINusoid|SQUare|TRIangle|RAMP|NOISe|USER}
Select the shape of the *modulating* waveform. You can use the noise function as the modulating waveform. However, you *cannot* use the noise function or dc volts as the carrier waveform. *The default is SIN.*
[*Stored in volatile memory*]

FM:INTernal:FUNCtion?
Query the shape of the modulating waveform. Returns "SIN", "SQU", "TRI", "RAMP", "NOIS", or "USER".

FM:INTernal:FREQuency {<*frequency*>|MINimum|MAXimum}
Set the frequency of the *modulating* waveform. Select from 10 mHz to 10 kHz. *The default is 10 Hz*. MIN = 10 mHz. MAX = 10 kHz.
[*Stored in volatile memory*]

FM:INTernal:FREQuency? [MINimum|MAXimum]
Query the modulating frequency. Returns a value in hertz.

FM:STATe {OFF|ON}
Disable or enable FM. To ensure proper operation, you should enable FM *after* you have set up the other modulation parameters. Only one modulation mode can be enabled at a time. When you enable FM, the previous modulation mode is turned off.

FM:STATe?
Query the state of FM. Returns "0" (OFF) or "1" (ON).

Burst Modulation Commands

See also "Burst Modulation," starting on page 81 in chapter 3.

Burst Modulation Overview

The following is an overview of the steps required to generate a burst-modulated waveform. *The commands used for burst modulation are listed on page 162.*

You can use burst modulation in the following two modes. The function generator enables one burst mode at a time based on the *trigger source* and *burst source* that you select (see the table below).

- *Triggered Burst Mode*: In this mode, the function generator outputs a waveform with a specified number of cycles (*burst count*) each time a trigger is received. After the specified number of cycles has been output, the function generator waits for the next trigger. You can configure the function generator to accept an internal trigger or you can send the trigger externally by pressing the front-panel Single key or by applying a trigger signal to the rear-panel *Ext Trig* terminal.

  At power-on, the internally-triggered burst mode is enabled.

- *External Gated Burst Mode*: In this mode, the output waveform is either "on" or "off" based on the level of the external signal applied to the rear-panel *Ext Trig* terminal. When the gate signal is true, the function generator outputs a continuous waveform. When the gate signal is false, the output is turned off.

	Trigger Source (TRIG:SOUR)	**Burst Source** (BM:SOUR)	**Burst Count** (BM:NCYC)	**Burst Rate** (BM:INT:RATE)	**Burst Phase** (BM:PHAS)
External Triggered Mode	External	Internal	Available	Not Used	Available
Internal Triggered Mode	Internal	Internal	Available	Available	Available
External Gated Mode	Internal	External	Not Used	Not Used	Not Used

1 Set up the burst carrier waveform.

Use the APPLy command or the equivalent FUNC:SHAP, FREQ, VOLT, and VOLT:OFFS commands to select the function, frequency, amplitude, and offset of the carrier waveform. You can select a sine, square, triangle, ramp, or arbitrary waveform for the carrier.

2 Set the burst count.

Set the burst count (number of cycles per burst) to any value between 1 and 50,000 cycles using the BM:NCYC command. *Used only in the triggered burst mode (internal or external source).*

3 Set the burst rate.

Set the burst rate (the frequency at which *internally* triggered bursts are generated) to any value between 10 mHz and 50 kHz using the BM:INT:RATE command. *Used only in the triggered burst mode with an internal trigger source.*

4 Set the burst starting phase.

Set the starting phase of the burst to any value between -360 degrees and +360 degrees using the BM:PHAS command. *Used only in the triggered burst mode (internal or external source).*

5 Select the trigger source or burst source.

- If you are using the *triggered burst* mode, select the trigger source using the TRIG:SOUR command.
- If you are using the *external gated burst* mode, select the external gate source using the BM:SOUR EXT command.

6 Enable burst modulation.

After you have set up the other modulation parameters, use the BM:STAT ON command to enable the burst mode.

Burst Modulation Commands

> *Use the* APPLy *command or the equivalent* FUNC:SHAP, FREQ, VOLT, *and* VOLT:OFFS *commands to configure the carrier waveform. Set the carrier frequency between 10 mHz and 5 MHz (100 kHz for triangle and ramp). The default is 1 kHz.*

BM:NCYCles {<# *cycles***>|INFinity|MINimum|MAXimum}**
Set the number of cycles to be output per burst (triggered burst mode only). Select from 1 cycle to 50,000 cycles, in 1 cycle increments. *The default is 1 cycle*. MIN = 1 cycle. MAX = 50,000 cycles. [*Stored in volatile memory*]

- For *sine, square,* and *arbitrary* waveforms (does not apply to ramp and triangle waveforms), the relationship between the carrier frequency and the minimum burst count is shown below.

Carrier Frequency	Minimum Burst Count
10 mHz to 1 MHz	1
>1 MHz to 2 MHz	2
>2 MHz to 3 MHz	3
>3 MHz to 4 MHz	4
>4 MHz to 5 MHz	5

For sine, square, and arbitrary waveforms only.

If you attempt to set the carrier frequency to a value that is not valid, the function generator will automatically adjust the frequency to the maximum value allowed with the present burst count. *From the remote interface, a -221, "Settings conflict" error is generated and the carrier frequency is adjusted.*

- For *all waveforms* used with burst, if the carrier frequency is set less than or equal to *100 Hz*, the following relationship applies.

$$\frac{\text{Burst Count}}{\text{Carrier Frequency}} \leq 500 \text{ seconds} \qquad \textit{For Carrier} \leq \textit{100 Hz}$$

  If you attempt to set the carrier frequency to a value that is not valid, the function generator will automatically adjust the frequency to the minimum value allowed with the present burst count. *From the remote interface, a -221, "Settings conflict" error is generated and the frequency is adjusted.*

BM:NCYCles? [MINimum|MAXimum]
Query the burst count. Returns an integer between 1 and 50,000.

BM:PHASe {<*degrees***>|MINimum|MAXimum}**
Set the starting phase for the burst (triggered burst mode only). Select from -360 degrees to +360 degrees, in 0.001 degree increments. *The default is 0 degrees*. MIN = -360 degrees. MAX = +360 degrees. [*Stored in volatile memory*]

- For *sine*, *square*, *triangle*, and *ramp* waveforms, 0 degrees is the point at which the waveform crosses zero volts (or the dc offset value), in a positive-going direction. For *arbitrary* waveforms, 0 degrees is the first point downloaded to memory.

BM:PHASe? [MINimum|MAXimum]
Query the starting phase. Returns a value in degrees.

BM:INTernal:RATE {<*frequency*>|MINimum|MAXimum}
Set the burst rate for internally triggered bursts. The burst rate frequency defines the interval between bursts. Select from 10 mHz to 50 kHz. *The default is 100 Hz*. MIN = 10 mHz. MAX = 50 kHz.
[*Stored in volatile memory*]

- The burst rate setting is used only when *internal* triggering is enabled (triggered mode). The burst rate is ignored when single triggering or external triggering is enabled.
- It is possible to specify a burst rate which is too fast for the function generator to output with the specified carrier frequency and burst count. If the burst rate is too high, the function generator will internally adjust it as needed to continuously re-trigger the burst. The adjustment is handled internally by the function generator (the burst rate displayed or queried will be the same as specified).

BM:INTernal:RATE? [MINimum|MAXimum]
Query the burst rate. Returns a value in hertz.

BM:SOURce {INTernal|EXTernal}
Select the burst modulation source. In the *external gated burst* mode, the output waveform is either "on" or "off" based on the level of the external signal applied to the rear-panel *Ext Trig* terminal. *The default is INT*. [*Stored in volatile memory*]

- When the *internal* burst source is selected, the external gated mode is disabled.
- When the *external gate* source is selected, the output is enabled or disabled based on the logic level of the gate signal applied to the *Ext Trig* terminal. When the gate signal is true (TTL high), the function generator outputs a continuous waveform. When the gate signal is false (TTL low), the output is turned off (zero volts or the dc offset level).
- When the *external gate* source is selected, the burst count, burst rate, burst phase, and burst trigger source are ignored (these parameters are used for the triggered burst mode only).

BM:SOURce?
Query the present burst modulation source. Returns "INT" or "EXT".

BM:STATe {OFF|ON}
Disable or enable burst modulation. To ensure proper operation, you should enable the burst mode *after* you have set up the other modulation parameters. Only one modulation mode can be enabled at a time. When you enable the burst mode, the previous modulation mode is turned off.

BM:STATe?
Query the state of burst modulation. Returns "0" (OFF) or "1" (ON).

TRIGger:SOURce {IMMediate|EXTernal|BUS}
Select the burst "trigger" source. In the *triggered burst* mode, the function generator outputs a waveform with the specified number of cycles (*burst count*) each time a trigger is received. After the specified number of cycles has been output, the function generator waits for the next trigger while outputting no signal (zero volts or the dc offset level). *The default is IMM*. [*Stored in volatile memory*]

- In the triggered burst mode, the "burst source" is *Internal*.
- When the *Immediate* (internal) trigger source is selected, the frequency at which the burst is generated is determined by the *burst rate* (`BM:INT:RATE`). The `APPLy` command automatically sets the trigger source to `IMMediate`.
- When the *External* trigger source is selected, the function generator will accept a hardware trigger applied to the rear-panel *Ext Trig* terminal. The function generator outputs the specified number of cycles each time *Ext Trig* receives the rising edge of a TTL pulse. The **Trig** annunciator turns on when the function generator is waiting for an external trigger.
- When the *Bus* (software) source is selected, the function generator outputs one burst each time a bus trigger command is received. To trigger the function generator from the remote interface (GPIB or RS-232), send the `*TRG` (trigger) command. *You can also trigger the function generator from the GPIB interface by sending the IEEE-488 Group Execute Trigger (GET) message* (e.g., `TRIGGER 710`).
- When the *External* or *Bus* trigger source is selected, the *burst count* and *burst phase* remain in effect but the *burst rate* is ignored.

TRIGger:SOURce *(continued)*

- When the *External gate* source is selected ("gated" burst mode), the specified trigger source is ignored. The external gated mode overrides the triggered mode source.
- To ensure synchronization when the *Bus* source is selected, send the `*WAI` (wait) command. When the `*WAI` command is executed, the function generator waits for all pending operations to complete before executing any additional commands. For example, the following command string guarantees that the first trigger is accepted and executed before the second trigger is recognized.

```
"TRIG:SOUR BUS;*TRG;*WAI;*TRG;*WAI"
```

- You can use the `*OPC?` (operation complete query) command or the `*OPC` (operation complete) command to signal when the burst is complete. The `*OPC?` command returns "1" to the output buffer when the burst is complete. The `*OPC` command sets the "operation complete" bit (bit 0) in the Standard Event register when the burst is complete.

`TRIGger:SOURce?`
Query the present trigger source. Returns "IMM", "EXT", or "BUS".

Frequency-Shift Keying (FSK) Commands

See also "FSK Modulation," starting on page 90 in chapter 3.

FSK Overview

The following is an overview of the steps required to generate an FSK waveform. The commands used for FSK are listed on the next page.

1 Set up the carrier waveform.

Use the `APPLy` command or the equivalent `FUNC:SHAP`, `FREQ`, `VOLT`, and `VOLT:OFFS` commands to select the function, frequency, amplitude, and offset of the carrier waveform. You can select a sine, square, triangle, ramp, or arbitrary waveform for the carrier.

2 Select the FSK "hop" frequency.

Use the `FSK:FREQ` command to set the "hop" frequency.

3 Set the FSK rate.

Use the `FSK:INT:RATE` command to set rate at which the output frequency "shifts" between the carrier frequency and the hop frequency (*internal FSK source only*).

4 Select the FSK source.

Select an internal or external FSK source using the `FSK:SOUR` command.

5 Enable FSK modulation.

After you have set up the other FSK parameters, use the `FSK:STAT ON` command to enable FSK modulation.

FSK Commands

> *Use the* APPLy *command or the equivalent* FUNC:SHAP, FREQ, VOLT, *and* VOLT:OFFS *commands to configure the carrier waveform. Set the carrier frequency between 10 mHz and 15 MHz (100 kHz for triangle and ramp). The default is 1 kHz.*

FSKey:FREQuency {<*frequency***>|MINimum|MAXimum}**
Set the FSK "hop" frequency. Select from 10 mHz to 15 MHz (100 kHz for triangle and ramp). *The default is 100 Hz*. MIN = 10 mHz. MAX = 15 MHz. [*Stored in volatile memory*]

FSKey:FREQuency? [MINimum|MAXimum]
Query the FSK "hop" frequency. Returns a value in hertz.

FSKey:INTernal:RATE {<*rate in Hz***>|MINimum|MAXimum}**
Set the rate at which the output frequency "shifts" between the carrier and hop frequency (FSK:SOUR INT only). Select from 10 mHz to 50 kHz. *The default is 10 Hz.* MIN = 10 mHz. MAX = 50 kHz.
[*Stored in volatile memory*]

The FSK rate is ignored when the external source is selected (FSK:SOUR EXT).

FSKey:INTernal:RATE? [MINimum|MAXimum]
Query the FSK rate. Returns a value in hertz.

FSKey:SOURce {INTernal|EXTernal}
Select an internal or external FSK source. *The default is INT*.
[*Stored in volatile memory*]

- When the *internal* source is selected, the rate at which the output frequency "shifts" between the carrier frequency and hop frequency is determined by the *FSK rate* specified (FSK:INT:RATE).
- When the *external* source is selected, the output frequency is determined by the signal level on the rear-panel *FSK* terminal. When a "low" TTL level is present, the carrier frequency is output. When a "high" TTL level is present, the hop frequency is output.
- The maximum external FSK rate is 1 MHz.
- The **Ext** annunciator turns on when the function generator is waiting for an external trigger signal.

FSKey:SOURce?
Query the internal FSK source. Returns "INT" or "EXT".

FSKey:STATe {OFF|ON}
Disable or enable FSK modulation. To ensure proper operation, you should enable FSK *after* you have set up the other modulation parameters. Only one modulation mode can be enabled at a time. When you enable FSK, the previous modulation mode is turned off.

FSKey:STATe?
Query the state of the FSK mode. Returns "0" (OFF) or "1" (ON).

Frequency Sweep Commands

See also "Frequency Sweep," starting on page 94 in chapter 3.

Sweep Overview

The following is an overview of the steps required to generate a frequency sweep. The commands used for frequency sweep are listed on the next page.

1 Select the waveform shape, amplitude, and offset.

Use the `APPLy` command or the equivalent `FUNC:SHAP`, `VOLT`, and `VOLT:OFFS` commands to select the function, amplitude, and offset of the sweep waveform. You can select a sine, square, triangle, ramp, or arbitrary waveform.

2 Select the start and stop frequencies.

Use the `FREQ:STAR` and `FREQ:STOP` commands to set the start and stop frequencies respectively.

*To sweep **up** in frequency, set the start frequency* **<** *stop frequency.*
*To sweep **down** in frequency, set the start frequency* **>** *stop frequency.*

3 Set the sweep time.

Use the `SWE:TIME` command to set the number of seconds required to sweep from the start frequency to the stop frequency.

4 Select the sweep mode.

Use the `SWE:SPAC` command to select *linear* or *logarithmic* spacing.

5 Select the sweep trigger source.

Use the `TRIG:SOUR` command to select the source from which the sweep will be triggered.

6 Enable sweep modulation.

Use the `SWE:STAT ON` command to enable the sweep mode.

Sweep Commands

> *To sweep **up** in frequency, set the start frequency* **<** *stop frequency.*
> *To sweep **down** in frequency, set the start frequency* **>** *stop frequency.*

FREQuency:STARt {<*frequency***>|MINimum|MAXimum}**
Set the start frequency. Select from 10 mHz to 15 MHz (100 kHz for triangle and ramp). The sweep is phase continuous over the full frequency range. *The default is 100 Hz*. MIN = 10 mHz. MAX = 15 MHz. [*Stored in volatile memory*]

FREQuency:STARt? [MINimum|MAXimum]
Query the start frequency. Returns a value in hertz.

FREQuency:STOP {<*frequency***>|MINimum|MAXimum}**
Set the stop frequency. Select from 10 mHz to 15 MHz (100 kHz for triangle and ramp). The sweep is phase continuous over the full frequency range. *The default is 1 kHz.* MIN = 10 mHz. MAX = 15 MHz. [*Stored in volatile memory*]

FREQuency:STOP? [MINimum|MAXimum]
Query the stop frequency. Returns a value in hertz.

SWEep:SPACing {LINear|LOGarithmic}
Select linear or logarithmic spacing for the sweep. *The default is Linear*. [*Stored in volatile memory*]

SWEep:SPACing?
Query the sweep mode. Returns “LIN” or “LOG”.

SWEep:TIME {<*seconds***>|MINimum|MAXimum}**
Set the number of seconds required to sweep from the start frequency to the stop frequency. Select from 1 ms to 500 seconds. *The default is 1 second*. MIN = 1 ms. MAX = 500 seconds. [*Stored in volatile memory*]

The number of frequency points in the sweep depends on the sweep time you select and is automatically calculated by the function generator.

SWEep:TIME? [MINimum|MAXimum]
Query the sweep time. Returns a value in seconds.

SWEep:STATe {OFF|ON}
Disable or enable the sweep mode. To ensure proper operation, you should enable the sweep mode *after* you have set up the other sweep parameters. Only one modulation mode can be enabled at a time. When you enable the sweep mode, the previous modulation mode is turned off.

SWEep:STATe?
Query the state of the sweep mode. Returns "0" (OFF) or "1" (ON).

TRIGger:SOURce {IMMediate|EXTernal|BUS}
Select the trigger source. In the *triggered sweep* mode, the function generator outputs a single sweep each time a trigger is received. After one sweep from the start frequency to the stop frequency, the function generators waits for the next trigger while outputting the start frequency. *The default is IMM.* [*Stored in volatile memory*]

- When the *Immediate* (internal) source is selected, the function generator outputs a continuous sweep at a rate determined by the sweep rate specified (`SWE:TIME`). The `APPLy` command automatically sets the trigger source to `IMMediate`.
- When the *External* source is selected, the function generator will accept a hardware trigger applied to the rear-panel *Ext Trig* terminal. The function generator outputs one sweep each time each time *Ext Trig* receives the rising edge of a TTL pulse. The **Trig** annunciator turns on when the function generator is waiting for an external trigger.
- When the *Bus* (software) source is selected, the function generator outputs one sweep each time a bus trigger command is received. To trigger the function generator from the remote interface (GPIB or RS-232), send the `*TRG` (trigger) command.
- To ensure synchronization when the *Bus* source is selected, send the `*WAI` (wait) command. When the `*WAI` command is executed, the function generator waits for all pending operations to complete before executing any additional commands. For example, the following command string guarantees that the first trigger is accepted and executed before the second trigger is recognized.

```
"TRIG:SOUR BUS;*TRG;*WAI;*TRG;*WAI"
```

- You can use the `*OPC?` (operation complete query) command or the `*OPC` (operation complete) command to signal when the sweep is complete. The `*OPC?` command returns “1” to the output buffer when the sweep is complete. The `*OPC` command sets the “operation complete” bit (bit 0) in the Standard Event register when the burst is complete.

`TRIGger:SOURce?`
Query the present trigger source. Returns “IMM”, “EXT”, or “BUS”.

Arbitrary Waveform Commands

See also "Arbitrary Waveforms" starting on page 103 in chapter 3.

Arbitrary Waveform Overview

The following is an overview of the steps required to download and output an arbitrary waveform over the remote interface. The commands used for arbitrary waveforms are listed on page 176. Refer to chapter 7, "Tutorial", for more information on the internal operation of downloading and outputting an arbitrary waveform.

> *Chapter 6, "Application Programs", contains several example programs which show the use of arbitrary waveforms. You may find it useful to refer to the programs after reading the following section in this chapter.*

1 Select the waveform frequency, amplitude, and offset.

Use the `APPLy` command or the equivalent `FREQ`, `VOLT`, and `VOLT:OFFS` commands to select the frequency, amplitude, and offset of the arbitrary waveform.

2 Download the data points into volatile memory.

You can download between 8 and 16,000 points per waveform. The waveform can be downloaded as floating-point values or binary integer values. Use the `DATA VOLATILE` command to download floating-point values between -1 and +1. Use the `DATA:DAC VOLATILE` command to download binary integer values between -2047 and +2047.

To ensure that binary data is downloaded properly, you must select the order in which the bytes are downloaded using the `FORM:BORD` *command.*

3 Copy the arbitrary waveform to non-volatile memory.

You can output the arbitrary waveform directly from volatile memory (as described in step 2) or you can copy the waveform to non-volatile memory. Use the `DATA:COPY` command to copy the waveform to non-volatile memory.

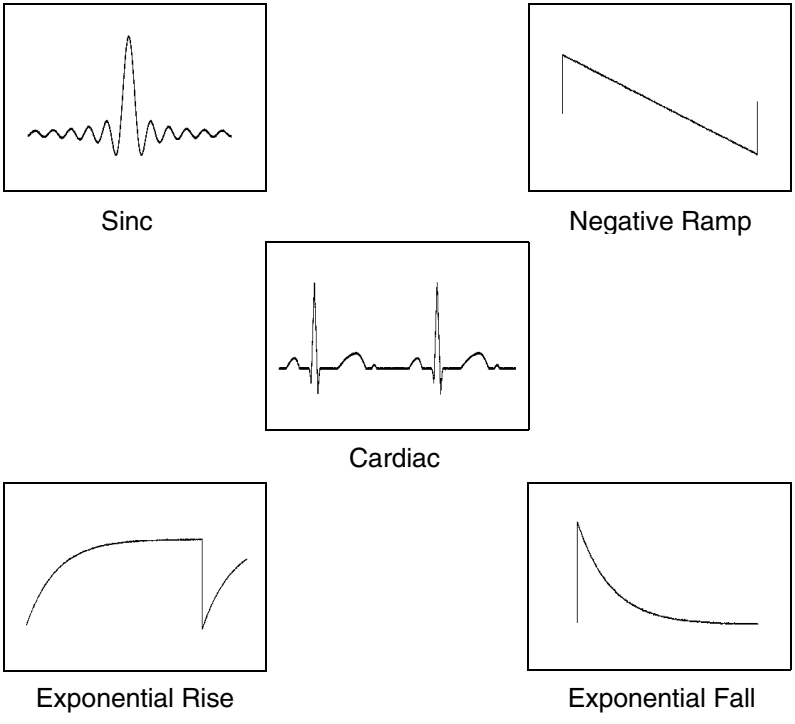
4 Select the arbitrary waveform to output.

You can select one of the five built-in arbitrary waveforms, one of four user-defined waveforms, or the waveform currently downloaded to volatile memory. Use the `FUNC:USER` command to select the waveform.

5 Output the currently selected arbitrary waveform.

Use the `FUNC:SHAP USER` command to output the waveform previously selected with the `FUNC:USER` command.

The five built-in arbitrary waveforms are shown below.



Arbitrary Waveform Commands

FUNCtion:USER {<*arb name***>|VOLATILE}**
Select one of the five built-in arbitrary waveforms, one of four user-defined waveforms, or the waveform currently downloaded to VOLATILE memory.

- The names of the five built-in arbitrary waveforms are: "SINC", "NEG_RAMP", "EXP_RISE", "EXP_FALL", and "CARDIAC".
- To select the waveform currently stored in volatile memory, specify the VOLATILE parameter. The keyword "VOLATILE" does not have a short form. The correct syntax is: `"FUNC:USER VOLATILE"`
- The `FUNC:USER` command *does not* output the selected waveform. Use the `FUNC:SHAP USER` command to output the waveform.
- If you select an arbitrary waveform name that is not currently downloaded, a *+785, "Specified arb waveform does not exist"* error is generated.
- The arb name may contain up to 8 characters. The first character *must* be a letter (A-Z), but the remaining characters can be numbers (0-9) or the underscore character (" _ "). Blank spaces are not allowed. If you specify a name with more than 8 characters, a *+783, "Arb waveform name too long"* error is generated.
- The function generator *does not* distinguish between upper- and lower-case letters for the arbitrary waveform name. Therefore, **ARB_1** and **arb_1** are the same name. All characters are converted to upper case.
- Use the `DATA:CAT?` command to list the names of the five built-in waveforms (non-volatile), "VOLATILE" if a waveform is currently downloaded to volatile memory, and the names of any user-defined waveforms (non-volatile).
- The following statement shows how to use the `FUNC:USER` command: `"FUNC:USER NEG_RAMP"`

FUNCtion:USER?
Query the arbitrary waveform currently selected. Returns "SINC", "NEG_RAMP", "EXP_RISE", "EXP_FALL", "CARDIAC", "VOLATILE", or the name of any user-defined waveforms in non-volatile memory.

FUNCtion:SHAPe USER
Select the function and output the selected arbitrary waveform. When executed, this command outputs the arbitrary waveform currently selected by the FUNC:USER command. The selected waveform is output using the previously selected frequency, amplitude, and offset settings.

- Use the FREQ, VOLT, and VOLT:OFFS commands to select the frequency, amplitude, and offset of the waveform. Or, use the APPLy command to select the function, frequency, amplitude, and offset with a single command.
- As shown in the following table, you can use the arbitrary waveform function with all of the modulation modes. Each "X" indicates a valid combination.

	Sine	Square	Triangle	Ramp	Noise	Arb
AM Carrier	X	X	X	X		X
AM Modulating Wave	X	X	X	X	X	X
FM Carrier	X	X	X	X		X
FM Modulating Wave	X	X	X	X	X	X
FSK Modulation	X	X	X	X		X
Burst Modulation	X	X	X	X		X
Frequency Sweep	X	X	X	X		X

- For arbitrary waveforms, the maximum amplitude will be limited if the data points do not span the full range of the output DAC (Digital-to-Analog Converter). For example, the built-in "SINC" waveform does not use the full range of values between ±1 and therefore its maximum amplitude is 6.084 Vpp (into 50 ohms).
- For arbitrary waveforms, the **Offset** annunciator will turn on if the waveform data has an inherent offset present (if the average is not equal to zero). The function generator calculates the average of the data points and compares the average to zero volts. If the average is not within two DAC (Digital-to-Analog Converter) counts of zero volts, the **Offset** annunciator turns on.

FUNCtion:SHAPe?
Query the output function. Returns "SIN", "SQU", "TRI", "RAMP", "NOIS", "DC", or "USER".

DATA VOLATILE, <*value*>, <*value*>, . . .
Download *floating-point* values between *-1* and *+1* into volatile memory. You can download between 8 and 16,000 points per waveform.

- The values -1 and +1 correspond to the peak values of the waveform. For example, if you set the amplitude to 10 Vpp, "-1" corresponds to -5 volts and "+1" corresponds to +5 volts.
- The maximum amplitude will be limited if the data points do not span the full range of the output DAC (Digital-to-Analog Converter). For example, the built-in "SINC" waveform does not use the full range of values between ±1 and therefore its maximum amplitude is 6.084 Vpp (into 50 ohms).
- Downloading floating-point values (using `DATA VOLATILE`) is slower than downloading binary values (using `DATA:DAC VOLATILE`) but is more convenient when using trigonometric functions which return values between -1 and +1.
- The `DATA VOLATILE` command overwrites the previous waveform in VOLATILE memory (no error is generated). Use the `DATA:COPY` command to copy the waveform to non-volatile memory.
- Up to four user-defined waveforms can be stored in non-volatile memory. Use the `DATA:DEL` command to delete the waveform in VOLATILE memory or any of the four user-defined waveforms in non-volatile memory. Use the `DATA:CAT?` command to list all waveforms currently stored in volatile and non-volatile memory (and the built-in waveforms).
- After downloading the waveform data to memory, use the `FUNC:USER` command to choose the active waveform and the `FUNC:SHAP USER` command to output it.
- The following statement shows how to use the `DATA VOLATILE` command to download nine points to volatile memory:

```
"DATA VOLATILE, 1,.75,.5,.25,0,-.25,-.5,-.75,-1"
```

DATA:DAC VOLATILE, {<*binary block***>|<***value***>, <***value***>, . . . }**
Download *binary integer* values between *-2047* and *+2047* into volatile memory. You can download between 8 and 16,000 points per waveform in IEEE-488.2 binary block format or as a list of values. The binary range of values corresponds to the values available using internal 12-bit DAC (Digital-to-Analog Converter) codes.

- The values -2047 and +2047 correspond to the peak values of the waveform. For example, if you have set the output amplitude to 10 Vpp, "-2047" corresponds to -5 volts and "+2047" corresponds to +5 volts.
- The maximum amplitude will be limited if the data points do not span the full range of the output DAC (Digital-to-Analog Converter). For example, the built-in "SINC" waveform does not use the full range of values between ±1 and therefore its maximum amplitude is 6.084 Vpp (into 50 ohms).
- The `DATA:DAC VOLATILE` command overwrites the previous waveform in VOLATILE memory (no error is generated). Use the `DATA:COPY` command to copy the waveform to non-volatile memory.
- Up to four user-defined waveforms can be stored in non-volatile memory. Use the `DATA:DEL` command to delete the waveform in VOLATILE memory or any of the four user-defined waveforms in non-volatile memory. Use the `DATA:CAT?` command to list all waveforms currently stored in volatile and non-volatile memory (and the built-in waveforms).
- After downloading the waveform data to memory, use the `FUNC:USER` command to choose the active waveform and the `FUNC:SHAP USER` command to output it.

DATA:DAC VOLATILE *(continued)*

- To download binary data over the RS-232 interface, you must select *8 data bits* with *no parity*. *See "RS-232 Interface Configuration" on page 195 for more information.*
- The following statement shows how to use the `DATA:DAC VOLATILE` command to download eight integer points using the binary block format (*see also "Using the IEEE-488.2 Binary Block Format" below*):

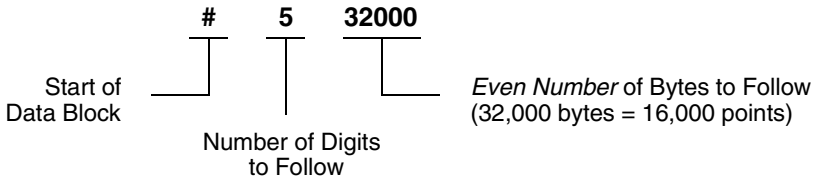
  `"DATA:DAC VOLATILE, #216` *Binary Data* `"`

- The following statement shows how to use the `DATA:DAC VOLATILE` command to download eight integer points:

```
"DATA:DAC VOLATILE, 2047,1536,1024,512,0,-512,-1536,-2047"
```

Using the IEEE-488.2 Binary Block Format

In the binary block format, a *block header* precedes the waveform data. The block header has the following format:



The function generator represents binary data as 12-bit integers, which is sent as two bytes. Therefore, **the total number of bytes is always twice the number of data points in the waveform** (and must always be an *even number*). For example, 32,000 bytes are required to download a waveform with 16,000 points.

Use the FORM:BORD command to select the byte order for binary transfers in block mode. If you specify FORM:BORD NORM (default), the most-significant byte (MSB) of each data point is sent first. If you specify FORM:BORD SWAP, the least-significant byte (LSB) of each data point is sent first. Most PCs use the "swapped" byte order.

DATA:ATTRibute:AVERage? [<*arb name*>]
Query the arithmetic *average* of all data points for the specified arbitrary waveform. The default *arb name* is the arbitrary waveform currently active (selected with FUNC:USER command).

- If you query a waveform that is not currently stored in memory, a +*785, "Specified arb waveform does not exist"* error is generated.

DATA:ATTRibute:CFACtor? [<*arb name*>]
Query the *crest factor* of all data points for the specified arbitrary waveform. Crest factor is the ratio of the peak value to the RMS value of the waveform. The default *arb name* is the arbitrary waveform currently active (selected with FUNC:USER command).

- If you query a waveform that is not currently stored in memory, a +*785, "Specified arb waveform does not exist"* error is generated.

DATA:ATTRibute:POINts? [<*arb name*>]
Query the number of points in the specified arbitrary waveform. Returns a value between 8 and 16,000 points. The default *arb name* is the arbitrary waveform currently active (selected with FUNC:USER command).

- If you query a waveform that is not currently stored in memory, a +*785, "Specified arb waveform does not exist"* error is generated.

DATA:ATTRibute:PTPeak? [<*arb name*>]
Query the *peak-to-peak* value of all data points for the specified arbitrary waveform. The default *arb name* is the arbitrary waveform currently active (selected with FUNC:USER command).

- This command returns a value between "0" and "+1.0", with "+1.0" indicating full amplitude available (100%).
- The maximum peak-to-peak amplitude will be limited if the data points do not span the full range of the output DAC (Digital-to-Analog Converter). For example, the built-in "SINC" waveform does not use the full range of values between ±1 and therefore its maximum peak-to-peak amplitude is 6.084 Vpp (into 50 ohms).
- If you query a waveform that is not currently stored in memory, a +*785, "Specified arb waveform does not exist"* error is generated.

DATA:CATalog?
List the names of *all* waveforms currently downloaded to memory. Returns the names of the five built-in waveforms (non-volatile memory), "VOLATILE" if a waveform is currently downloaded to volatile memory, and all user-defined waveforms downloaded to non-volatile memory.

- A series of quoted strings separated with commas is returned:

```
"SINC","NEG_RAMP","EXP_RISE","EXP_FALL",
"CARDIAC","VOLATILE","ARB_1","ARB_2"
```

- Use the DATA:DEL command to delete the waveform in VOLATILE memory or any of the user-defined waveforms in non-volatile memory.

DATA:COPY <*destination arb name***> [,VOLATILE]**
Copy the waveform from volatile memory to the specified name in non-volatile memory. The source for the copy is always "VOLATILE" (you cannot copy from any other name) and you cannot *copy to* VOLATILE. The VOLATILE parameter is optional and can be omitted.

- The arb name may contain up to 8 characters. The first character *must* be a letter (A-Z), but the remaining characters can be numbers (0-9) or the underscore character (" _ "). Blank spaces are not allowed. If you specify a name with more than 8 characters, a *+783, "Arb waveform name too long"* error is generated.
- The following built-in waveform names are reserved and cannot be used with the DATA:COPY command: SINC, NEG_RAMP, EXP_RISE, EXP_FALL, and CARDIAC. If you specify one of the built-in waveforms, a *+782, "Cannot overwrite a built-in arb waveform"* error is generated.
- The function generator *does not* distinguish between upper- and lower-case letters. Therefore, **ARB_1** and **arb_1** are the same name. All characters are converted to upper case.

- If you copy to a waveform name that already exists, the previous waveform is overwritten (no error is generated). However, you cannot overwrite any of the five built-in waveforms.
- Up to four user-defined waveforms can be stored in non-volatile memory. If memory is full and you try to copy a new waveform to non-volatile memory, a *+781, "Not enough memory"* error is generated. Use the `DATA:DEL` command to delete the waveform in VOLATILE memory or any of the four user-defined waveforms in non-volatile memory. Use the `DATA:CAT?` command to list all waveforms currently stored in volatile and non-volatile memory.
- The following statement shows how to use the `DATA:COPY` command:

```
"DATA:COPY ARB_1, VOLATILE"
```

`DATA:DELete` **<***arb name***>**
Delete the specified arbitrary waveform from memory. You can delete the waveform in volatile memory or any of the four user-defined waveforms in non-volatile memory.

- You cannot delete the arbitrary waveform that is currently being output. If you attempt to delete the waveform being output, a *+787, "Cannot delete an active arb waveform"* error is generated.
- You cannot delete any of the five built-in arbitrary waveforms. If you attempt to delete one of the built-in waveforms, a *+786, "Cannot delete a built-in arb waveform"* error is generated.
- Use the `DATA:DEL:ALL` command to delete the waveform in VOLATILE memory and all user-defined non-volatile waveforms *all at once*. If one of the waveforms is currently being output, a *+787, "Cannot delete an active arb waveform"* error is generated. The active waveform *is not* deleted but all of the other waveforms are deleted.

DATA:DELete:ALL
Delete all user-defined arbitrary waveforms from memory. This command deletes the waveform in VOLATILE memory and all user-defined waveforms in non-volatile memory. The five built-in waveforms in non-volatile memory *are not* deleted.

- The colon before the ALL parameter is required.

  ```
  DATA:DELete:ALL
  ```

  If you insert a space instead of a colon, the function generator will attempt to delete an arbitrary waveform with the name "ALL". If no such waveform is stored in memory, a *+785, "Specified arb waveform does not exist"* error is generated.

- You cannot delete the arbitrary waveform that is currently being output. If you attempt to delete the waveform being output, a *+787, "Cannot delete an active arb waveform"* error is generated.
- You cannot delete any of the five built-in arbitrary waveforms. If you attempt to delete one of the built-in waveforms, a *+786, "Cannot delete a built-in arb waveform"* error is generated.
- Use the DATA:DEL <*arb name*> command to delete stored waveforms *one at a time*.

DATA:NVOLatile:CATalog?
List the names of all user-defined arbitrary waveforms currently downloaded to non-volatile memory. Returns the names of up to four waveforms in non-volatile memory.

- A series of quoted strings separated with commas is returned (see example below). If no user-defined waveforms are currently downloaded to non-volatile memory, the command returns a null string ("").

  ```
  "ARB_1","ARB_2","ARB_3","ARB_4"
  ```

- Use the DATA:DEL command to delete the waveform in VOLATILE memory or any of the user-defined waveforms in non-volatile memory.

DATA:NVOLatile:FREE?
Query the number of non-volatile *memory slots* available to store user-defined waveforms. Non-volatile waveform memory is divided into four 16k-point slots. This command returns the number of memory slots available to store user-defined waveforms: "0" (memory is full), "1", "2", "3", or "4".

FORMat:BORDer {NORMal|SWAPped}
Used only for binary block transfers. Select the byte order for binary transfers in the block mode using the DATA:DAC command. *The default is NORM*.

- In *NORM* byte order (default), the most-significant byte (MSB) of each data point is sent first.
- In *SWAP* byte order, the least-significant byte (LSB) of each data point is sent first. Most PCs use the "swapped" byte order.
- The function generator represents binary data as 12-bit integers, which are sent as two bytes. Each data point in the waveform requires 12 bits, which must be transferred as 16 bits (two bytes) on the function generator's 8-bit interface.

FORMat:BORDer?
Query the byte order configuration. Returns "NORM" or "SWAP".

SCPI

First-time SCPI users, see page 211.

Triggering

See also "Triggering," starting on page 98 in chapter 3.

Applies only to burst modulation and frequency sweep. You can issue triggers for bursts and sweeps using an *immediate* trigger, an *external* trigger, or a *bus* trigger.

`TRIGger:SOURce {IMMediate|EXTernal|BUS}`
Select the source from which the function generator will accept a trigger. The function generator will accept an immediate internal trigger, a hardware trigger from the rear-panel *Ext Trig* terminal, or a software (bus) trigger. *The default is Immediate*.
[*Stored in volatile memory*]

- When the *Immediate* (internal) source is selected, the function generator outputs continuously when the burst mode or sweep mode is enabled. The `APPLy` command automatically sets the trigger source to `IMMediate`.
- When the *External* source is selected, the function generator will accept a hardware trigger applied to the rear-panel *Ext Trig* terminal. The function generator outputs one burst or initiates one sweep each time each time *Ext Trig* receives the rising edge of a TTL pulse. The **Trig** annunciator turns on when the function generator is waiting for an external trigger.
- When the *Bus* (software) source is selected, the function generator outputs one burst or initiates one sweep each time a bus trigger command is received. To trigger the function generator from the remote interface (GPIB or RS-232), send the `*TRG` (trigger) command. *You can also trigger the function generator from the GPIB interface by sending the IEEE-488 Group Execute Trigger (GET) message* (e.g., `TRIGGER 710`).

- To ensure synchronization when the *Bus* source is selected, send the `*WAI` (wait) command. When the `*WAI` command is executed, the function generator waits for all pending operations to complete before executing any additional commands. For example, the following command string guarantees that the first trigger is accepted and executed before the second trigger is recognized.

```
"TRIG:SOUR BUS;*TRG;*WAI;*TRG;*WAI"
```

- You can use the `*OPC?` (operation complete query) command or the `*OPC` (operation complete) command to signal when the burst or sweep is complete. The `*OPC?` command returns "1" to the output buffer when the burst or sweep is complete. The `*OPC` command sets the "operation complete" bit (bit 0) in the Standard Event register when the burst or sweep is complete.

TRIGger:SOURce?
Query the present trigger source. Returns "IMM", "EXT", or "BUS".

TRIGger:SLOPe {POSitive|NEGative}
Select the polarity of the *Ext Trig* terminal. If you select "POS", the polarity of the *Ext Trig* terminal is the same as described on page 102. If you select "NEG", the polarity is the opposite of what is described. *The default is Positive.* [*Stored in volatile memory*]

TRIGger:SLOPe?
Query the present polarity of the *Ext Trig* terminal. Returns "POS" or "NEG".

***TRG**
Trigger the function generator from the remote interface. For RS-232 operation, make sure the interface is in the remote mode by sending the `SYST:REM` command.

System-Related Commands

See also "System-Related Operations," starting on page 109 in chapter 3.

DISPlay {OFF|ON}
Turn the front-panel display off or on. When the display is turned off, output parameters are not sent to the display and all annunciators except **ERROR** and **Shift** are disabled. Front-panel operation is otherwise unaffected by turning off the display. [*Stored in volatile memory*]

- Sending a message to the display from the remote interface overrides the display state; this means that you can display a message even if the display is turned off.
- The display state is automatically turned on when you return to the local (front panel) state. Press the Shift key or execute `LOCAL 710` from the remote interface to return to the local state.

DISPlay?
Query the front-panel display setting. Returns "0" (OFF) or "1" (ON).

DISPlay:TEXT <*quoted string***>**
Display a message containing up to 11 characters on the front panel; any additional characters are truncated. Commas, periods, and semicolons share a display space with the preceding character, and *are not* considered individual characters. When a message is displayed, information relating to the output waveform (such as frequency and amplitude) is not sent to the display. [*Stored in volatile memory*]

The `DISP:TEXT` *command is allowed only while the function generator is in the remote mode. An error is generated if you attempt to execute the command while in the local mode.*

The following command string shows how to display a message on the front panel.

```
"DISP:TEXT 'HELLO'"
```

DISPlay:TEXT?
Query the message sent to the front panel and return a quoted string. For example, the query returns a string such as `"HELLO"`.

DISPlay:TEXT:CLEar
Clear the message displayed on the front panel.

SYSTem:BEEPer
Issue a single beep immediately.

SYSTem:ERRor?
Read one error from the *error queue.* When the front-panel **ERROR** annunciator turns on, one or more command syntax or hardware errors have been detected. A record of up to 20 errors can be stored in the function generator's error queue. *See chapter 5, "Error Messages," for a complete listing of the errors.*

- Errors are retrieved in first-in-first-out (FIFO) order. The first error returned is the first error that was stored. When you have read all errors from the queue, the **ERROR** annunciator turns off. The function generator beeps once each time an error is generated.
- If more than 20 errors have occurred, the last error stored in the queue (the most recent error) is replaced with *-350, "Too many errors"*. No additional errors are stored until you remove errors from the queue. If no errors have occurred when you read the error queue, the function generator responds with *+0, "No error"*.
- The error queue is cleared when power has been off or after a `*CLS` (clear status) command has been executed. The `*RST` (reset) command *does not* clear the error queue.
- Errors have the following format (the error string may contain up to *80 characters*):

```
-113,"Undefined header"
```

SYSTem:VERSion?
Query the function generator to determine the present SCPI version. Returns a string in the form "YYYY.V" where the "Y's" represent the year of the version, and the "V" represents a version number for that year (for example, 1993.0).

***IDN?**
Read the function generator's identification string. The function generator returns four fields separated by commas. The *first* field is the manufacturer's name, the *second* field is the model number, the *third* field is not used (always "0"), and the *fourth* field is a revision code which contains three numbers. The first number is the firmware revision number for the *main generator processor*; the second is for the *input/output processor*; and the third is for the *front-panel processor*.

- The command returns a string with the following format (be sure to dimension a string variable with at least *40 characters*):

```
HEWLETT-PACKARD,33120A,0,X.X-X.X-X.X
```

***RST**
Reset the function generator to its default state (*see "Power-On and Reset State" on page 123*) independent of the POWER ON command setting in the front-panel SYS MENU.

In the sweep mode, the `*RST` *command* ***does not*** *set the start and stop frequencies to their default values. Instead, the reset operation sets the start frequency to 10 mHz (minimum) and the stop frequency to 15 MHz (maximum).*

***TST?**
Perform a complete self-test of the function generator. Returns "+0" if the self-test passes or "+1" if it fails. If the self-test fails, an error message is also generated with additional information on why the test failed.

***SAV {0|1|2|3}**
Store up to four different instrument configurations.
[*Stored in non-volatile memory*]

- Four memory locations (numbered 0, 1, 2, and 3) are available to store instrument configurations. The state storage feature "remembers" the function (including arbitrary waveforms), frequency, amplitude, dc offset, duty cycle, as well as any modulation parameters. To recall a stored state, you must use the same memory location used previously to store the state.
- From the remote interface only, you can use memory location "0" to store a fourth instrument configuration (you cannot store to this memory location from the front panel). However, keep in mind that memory location "0" is automatically overwritten when the power is turned off.
- Any arbitrary waveforms downloaded to "VOLATILE" memory *are not* remembered. However, if an arbitrary waveform is being output from *non-volatile* memory when the state is stored, the waveform data is stored. The stored waveform is output when the instrument state is recalled.
- If you delete an arbitrary waveform after storing the state, the waveform data is lost and the function generator will not output the waveform when the state is recalled. The "SINC" waveform is output in place of the deleted waveform.
- When power is turned off, the function generator automatically stores its state in memory location "0". You can configure the function generator to automatically recall the power-down state when power is restored. The recall mode is *disabled* when the function generator is shipped from the factory.

  Select the POWER ON LAST STATE command from the SYS MENU to enable the power-down recall mode. Select POWER ON DEFAULT to disable the power-down recall mode. *See "Power-Down Recall Mode" on page 109 for more information.*

***RCL {0|1|2|3}**
Recall a previously stored state. To recall a stored state, you must use the same memory location used previously to store the state.

- You cannot recall the instrument state from a memory location that was not previously specified as a storage location. For example, an error is generated if you attempt to recall from memory location "2" but have never stored to that location. *From the remote interface, a +810, "State has not been stored" error is generated if nothing is stored in the specified memory location.*

MEMory:STATe:DELete {0|1|2|3}
Delete a previously stored state and clear the memory location.
If nothing is stored in the specified memory location, a *+810, "State has not been stored"* error is generated.

***OPC**
Set the "operation complete" bit (bit 0) in the Standard Event register after the previous commands have been executed. *Used only in the triggered burst mode and triggered sweep mode.*

***OPC?**
Return "1" to the output buffer after the previous commands have been executed. *Used only in the triggered burst mode and triggered sweep mode.*

***WAI**
Wait for all pending operations to complete before executing any additional commands over the interface. *Used only in the triggered burst mode and triggered sweep mode.*

Calibration Commands

See "Calibration Overview" starting on page 118 for an overview of the calibration features of the function generator. For a more detailed discussion of the calibration procedures, see chapter 4 in the Service Guide.

CALibration?
Perform a calibration using the specified calibration value (CAL:VAL command). Before you can calibrate the function generator, you must unsecure it by entering the correct security code.

CALibration:COUNt?
Query the function generator to determine the number of times it has been calibrated. Your function generator was calibrated before it left the factory. When you receive your function generator, read the count to determine its initial value. [*Stored in non-volatile memory*]

- The calibration count increments up to a maximum of 32,767 after which it wraps-around to 0. Since the value increments by one for each calibration point, a complete calibration will increase the value by many counts.

CALibration:SECure:CODE <*new code***>**
Enter a new security code. To change the security code, you must first unsecure the function generator using the old security code, and then enter a new code. The calibration code may contain up to 12 characters. [*Stored in non-volatile memory*]

CALibration:SECure:STATe {OFF|ON},<*code***>**
Unsecure or secure the function generator for calibration. The calibration code may contain up to 12 characters. [*Stored in non-volatile memory*]

CALibration:SECure:STATe?
Query the secured state of the function generator. Returns "0" (OFF) or "1" (ON).

CALibration:SETup <0|1|2|3| ... |84>
Configure the function generator's internal state for each of the calibration steps to be performed.

CALibration:SETup?
Query the calibration setup number. Returns a value between 0 and 84.

CALibration:STRing <*quoted string***>**
Record calibration information about your function generator. For example, you can store such information as the last calibration date, the next calibration due date, the instrument serial number, or even the name and phone number of the person to contact for a new calibration. [*Stored in non-volatile memory*]

- You can record information in the calibration message only from the remote interface. However, you can read the message from either the front-panel menu or the remote interface.
- The calibration message may contain up to 40 characters. However, the function generator can display only 11 characters of the message on the front panel (additional characters are truncated).

CALibration:STRing?
Query the calibration message and return a quoted string.

CALibration:VALue <*value***>**
Specify the value of the known calibration signal used by the calibration procedure. Use the `CAL:SET` command to configure the function generator's internal state for each of the calibration steps to be performed.

CALibration:VALue?
Query the present calibration value.

RS-232 Interface Configuration

See also "Remote Interface Configuration," on page 114 in chapter 3.

You connect the function generator to the RS-232 interface using the 9-pin (DB-9) serial connector on the rear panel. The function generator is configured as a DTE (*Data Terminal Equipment*) device. For all communications over the RS-232 interface, the function generator uses two handshake lines: DTR (*Data Terminal Ready*) on pin 4 and DSR (*Data Set Ready*) on pin 6.

The following sections contain information to help you use the function generator over the RS-232 interface. The programming commands for RS-232 are listed on page 200.

RS-232 Configuration Overview

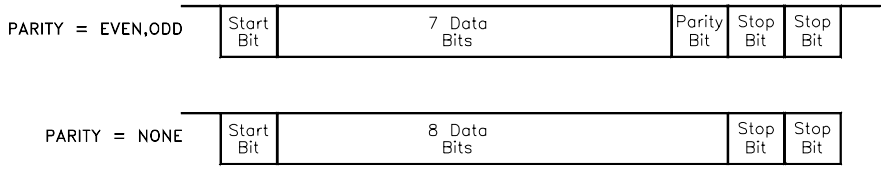
Configure the RS-232 interface using the parameters shown below. Use the front-panel I/O MENU to select the baud rate, parity, and number of data bits (*see also pages 219 and 220 for more information*).

- Baud Rate: 300, 600, 1200, 2400, 4800, or **9600 baud** (*factory setting*)
- Parity and Data Bits: **None / 8 data bits** (*factory setting)*
  Even / 7 data bits, or
  Odd / 7 data bits
- Number of Start Bits: **1 bit** (*fixed*)
- Number of Stop Bits: **2 bits** (*fixed*)

> *To download binary data for arbitrary waveforms over the RS-232 interface, you must select **8 data bits** with **no parity**.*

RS-232 Data Frame Format

A character *frame* consists of all the transmitted bits that make up a single character. The frame is defined as the characters from the *start bit* to the last *stop bit*, inclusively. Within the frame, you can select the baud rate, number of data bits, and parity type. The function generator uses the following frame formats for seven and eight data bits.



Connection to a Computer or Terminal

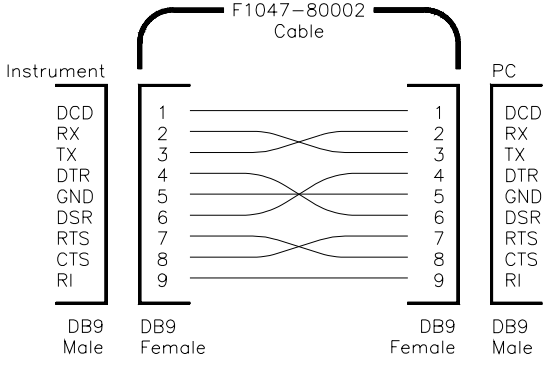
To connect the function generator to a computer or terminal, you must have the proper interface cable. Most computers and terminals are DTE (*Data Terminal Equipment*) devices. Since the function generator is also a DTE device, you must use a DTE-to-DTE interface cable. These cables are also called *null-modem*, *modem-eliminator*, or *crossover* cables.

The interface cable must also have the proper connector on each end and the internal wiring must be correct. Connectors typically have 9 pins (DB-9 connector) or 25 pins (DB-25 connector) with a “male” or “female” pin configuration. A male connector has pins inside the connector shell and a female connector has holes inside the connector shell.

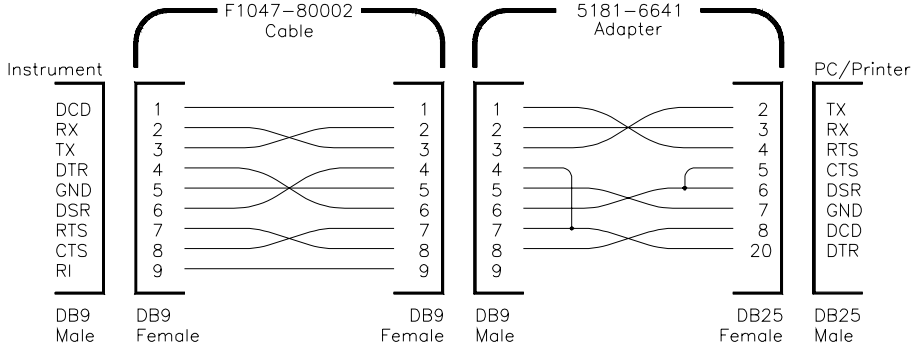
If you cannot find the correct cable for your configuration, you may have to use a *wiring adapter*. If you are using a DTE-to-DTE cable, make sure the adapter is a “straight-through” type. Typical adapters include gender changers, null-modem adapters, and DB-9 to DB-25 adapters.

Refer to the cable and adapter diagrams on the following page to connect the function generator to most computers or terminals. If your configuration is different than those described, order the *34399A Adapter Kit*. This kit contains adapters for connection to other computers, terminals, and modems. Instructions and pin diagrams are included with the adapter kit.

DB-9 Serial Connection If your computer or terminal has a 9-pin serial port with a male connector, use the null-modem cable included with the *34398A Cable Kit*. This cable has a 9-pin female connector on each end. The cable pin diagram is shown below.



DB-25 Serial Connection If your computer or terminal has a 25-pin serial port with a male connector, use the null-modem cable and 25-pin adapter included with the *34398A Cable Kit*. The cable and adapter pin diagram is shown below.



DTR / DSR Handshake Protocol

The function generator is configured as a DTE (*Data Terminal Equipment*) device and uses the DTR (*Data Terminal Ready*) and DSR (*Data Set Ready*) lines of the RS-232 interface to handshake. The function generator uses the DTR line to send a hold-off signal. The DTR line must be TRUE before the function generator will accept data from the interface. When the function generator sets the DTR line FALSE, the data must cease within 10 characters.

To disable the DTR/DSR handshake, *do not* connect the DTR line and tie the DSR line to logic TRUE. If you disable the DTR/DSR handshake, also select a slower baud rate (300, 600, or 1200 baud) to ensure that the data is transmitted correctly.

The function generator sets the DTR line FALSE in the following cases:

1 When the function generator's input buffer is full (when approximately 100 characters have been received), it sets the DTR line FALSE (pin 4 on the RS-232 connector). When enough characters have been removed to make space in the input buffer, the function generator sets the DTR line TRUE, unless the second case (see below) prevents this.

2 When the function generator wants to "talk" over the interface (which means that it has processed a query) and has received a <*new line*> message terminator, it will set the DTR line FALSE. This implies that once a query has been sent to the function generator, the controller should read the response before attempting to send more data. It also means that a <*new line*> must terminate the command string. After the response has been output, the function generator sets the DTR line TRUE again, unless the first case (see above) prevents this.

The function generator monitors the DSR line to determine when the controller is ready to accept data over the interface. The function generator monitors the DSR line (pin 6 on the RS-232 connector) before each character is sent. The output is suspended if the DSR line is FALSE. When the DSR line goes TRUE, transmission will resume.

The function generator holds the DTR line FALSE while output is suspended. A form of interface *deadlock* exists until the controller asserts the DSR line TRUE to allow the function generator to complete the transmission. You can break the interface deadlock by sending the <*Ctrl-C*> character, which clears the operation in progress and discards pending output (this is equivalent to the IEEE-488 device clear action).

For the <Ctrl-C> character to be recognized reliably by the function generator while it holds DTR FALSE, the controller must first set DSR FALSE. When downloading binary data for an arbitrary waveform, press the front-panel LOCAL key first and then send <Ctrl-C>.

RS-232 Troubleshooting

Here are a few things to check if you are having problems communicating over the RS-232 interface. If you need additional help, refer to the documentation that came with your computer.

- Verify that the function generator and your computer are configured for the same baud rate, parity, and number of data bits. Make sure that your computer is set up for *1 start bit* and *2 stop bits* (these values are fixed on the function generator).
- Make sure to execute the `SYSTEM:REMOTE` command to place the function generator in the REMOTE mode.
- Verify that you have connected the correct interface cable and adapters. Even if the cable has the proper connectors for your system, the internal wiring may not be correct. The *34398A Cable Kit* can be used to connect the function generator to most computers or terminals.
- Verify that you have connected the interface cable to the correct serial port on your computer (COM1, COM2, etc).

RS-232 Interface Commands

Use the front-panel I/O MENU to select the baud rate, parity, and number of data bits (see pages 219 and 220 for more information).

SYSTem:LOCal
Place the function generator in the *local* mode for RS-232 operation. All keys on the front panel are fully functional.

SYSTem:REMote
Place the function generator in the *remote* mode for RS-232 operation. All keys on the front panel, except the LOCAL key, are disabled.

> *It is very important that you send the* **SYSTEM:REMOTE** *command to place the function generator in the remote mode. Sending or receiving data over the RS-232 interface when not configured for remote operation can cause unpredictable results.*

SYSTem:RWLock
Place the function generator in the *remote* mode for RS-232 operation. This command is the same as the SYSTEM:REMOTE command except that *all keys* on the front panel are disabled, including the LOCAL key.

Ctrl-C
Clear the operation in progress over the RS-232 interface and discard any pending output data. *This is equivalent to the IEEE-488 device clear action over the GPIB interface.*

The SCPI Status Registers

The function generator uses the *Status Byte* register group and the *Standard Event* register group to record various instrument conditions. A diagram of the SCPI status system is shown on the next page.

> *An example program is included in chapter 6, "Application Programs," which shows the use of the status registers. You may find it useful to refer to the program after reading the following section in this chapter.*

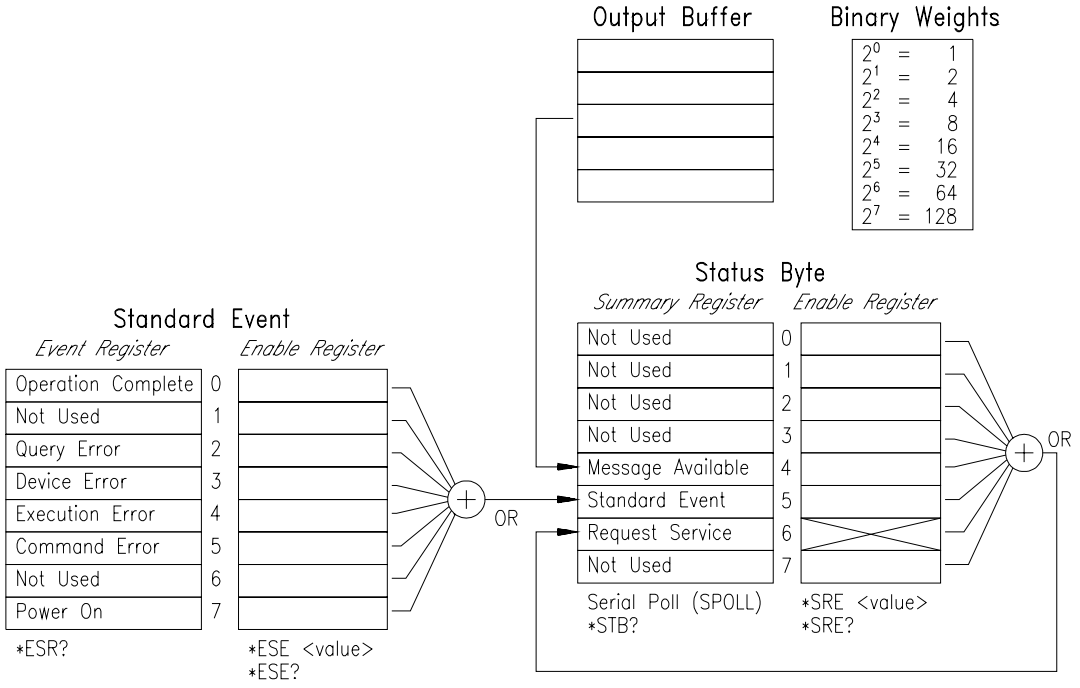
What is an *Event Register*?

An *event register* is a read-only register that reports defined conditions within the function generator. Bits in an event register *are latched*. When an event bit is set, subsequent state changes are ignored. Bits in an event register are automatically cleared by a query of that register or by sending the `*CLS` (clear status) command. The `*RST` (reset) command or device clear will not clear bits in an event register. Querying an event register returns a decimal value which corresponds to the binary-weighted sum of all bits set in the register.

What is an *Enable Register*?

An *enable register* defines which bits in the corresponding event register are logically ORed together to form a single summary bit. You can read from, and write, to an enable register. Querying an enable register *will not* clear it. The `*CLS` (clear status) command does not clear enable registers but it does clear the bits in the event registers. To enable bits in an enable register, you must write a decimal value which corresponds to the binary-weighted sum of the bits you wish to enable in the register.

SCPI Status System



The Status Byte Register

The Status Byte *summary register* reports conditions from the other status registers. Query data that is waiting in the function generator's output buffer is immediately reported through the "message available" bit (bit 4). Bits in the summary register are *not latched*. Clearing an event register will clear the corresponding bits in the Status Byte summary register. Reading all messages in the output buffer, including any pending queries, will clear the message available bit.

Bit Definitions – Status Byte Register

Bit	Decimal Value	Definition
0 Not Used	1	Always set to 0.
1 Not Used	2	Always set to 0.
2 Not Used	4	Always set to 0.
3 Not Used	8	Always set to 0.
4 Message Available	16	Data is available in the output buffer.
5 Standard Event	32	One or more bits are set in the Standard Event register (bits must be "enabled" in enable register).
6 Request Service	64	Requesting service (serial poll).
7 Not Used	128	Always set to 0.

***The Status Byte Summary Register is cleared when*:**

- You execute the `*CLS` (clear status) command.
- Querying the Standard Event register (`*ESR?` command) will clear only bit 4 in the Summary Register.

***The Status Byte Enable Register (request service) is cleared when*:**

- You execute the `*SRE 0` command.
- You turn on the power and have previously configured the function generator using the `*PSC 1` command.
- The enable register *will not* be cleared at power-on if you have previously configured the function generator using `*PSC 0`.

Using Service Request (SRQ) and Serial POLL

You must configure your bus controller to respond to the IEEE-488 service request (SRQ) interrupt to use this capability. Use the Status Byte enable register (`*SRE` command) to select which summary bits will set the low-level IEEE-488 service request signal. When bit 6 (request service) is set in the Status Byte, an IEEE-488 service request interrupt message is automatically sent to the bus controller. The bus controller may then poll the instruments on the bus to identify which one requested service (the instrument with bit 6 set in its Status Byte).

The request service bit is cleared only by reading the Status Byte using an IEEE-488 serial poll or by reading the event register whose summary bit is causing the service request.

To read the Status Byte summary register, send the IEEE-488 serial poll message. Querying the summary register will return a decimal value which corresponds to the binary-weighted sum of the bits set in the register. Serial poll will automatically clear the “request service” bit in the Status Byte summary register. No other bits are affected. Performing a serial poll will not affect instrument throughput.

Caution

The IEEE-488.2 standard does not ensure synchronization between your bus controller program and the instrument. Use the `*OPC?` command to guarantee that commands previously sent to the instrument have completed. Executing a serial poll before a `*RST`, `*CLS`, or other commands have completed can cause previous conditions to be reported.

Using *STB? to Read the Status Byte

The `*STB?` (status byte query) command is similar to a serial poll but it is processed like any other instrument command. The `*STB?` command returns the same result as a serial poll but the "request service" bit (bit 6) *is not* cleared if a serial poll has occurred.

The `*STB?` command is not handled automatically by the IEEE-488 bus interface hardware and will be executed *only* after previous commands have completed. Polling is not possible using the `*STB?` command. Executing the `*STB?` command does not clear the Status Byte summary register.

Using the Message Available Bit (MAV)

You can use the Status Byte "message available" bit (bit 4) to determine when data is available to read into your bus controller. The function generator subsequently clears bit 4 *only* after all messages have been read from the output buffer.

To Interrupt Your Bus Controller Using SRQ

1. Send a device clear message to clear the function generator's output buffer (e.g., `CLEAR 710`).
2. Clear the event registers with the `*CLS` (clear status) command.
3. Set up the enable register masks. Execute the `*ESE` command to set up the Standard Event register and the `*SRE` command for the Status Byte.
4. Send the `*OPC?` (operation complete query) command and enter the result to ensure synchronization.
5. Enable your bus controller's IEEE-488 SRQ interrupt.

To Determine When a Command Sequence is Completed

1. Send a device clear message to clear the function generator's output buffer (e.g., `CLEAR 710`).

2. Clear the event registers with the `*CLS` (clear status) command.

3. Enable the "operation complete" bit (bit 0) in the Standard Event register by executing the `*ESE 1` command.

4. Send the `*OPC?` (operation complete query) command and enter the result to ensure synchronization.

5. Execute your command string to program the desired configuration, and then execute the `*OPC` (operation complete) command as the last command. When the command sequence is completed, the "operation complete" bit (bit 0) is set in the Standard Event register.

6. Use a serial poll to check to see when bit 5 (standard event) is set in the Status Byte summary register. You could also configure the function generator for an SRQ interrupt by sending `*SRE 32` (Status Byte enable register, bit 5).

The Standard Event Register

The Standard Event register reports the following types of instrument events: power-on detected, command syntax errors, command execution errors, self-test or calibration errors, query errors, or when an `*OPC` command is executed. Any or all of these conditions can be reported in the Standard Event summary bit through the *enable register*. To set the enable register mask, you write a decimal value to the register using the `*ESE` (event status enable) command.

> *An error condition (Standard Event register bits 2, 3, 4, or 5) will always record one or more errors in the function generator's error queue. Read the error queue using the* `SYSTem:ERRor?` *command.*

Bit Definitions – Standard Event Register

Bit	Decimal Value	Definition
0 Operation Complete	1	All commands prior to and including an *OPC command have been executed.
1 Not Used	2	Always set to 0.
2 Query Error	4	The function generator tried to read the output buffer but it was empty. Or, a new command line was received before a previous query has been read. Or, both the input and output buffers are full.
3 Device Error	8	A self-test or calibration error occurred (see error numbers 501 through 857 in chapter 5).
4 Execution Error	16	An execution error occurred (see error numbers -211 through -224 in chapter 5).
5 Command Error	32	A command syntax error occurred (see errors -101 through -168 in chapter 5).
6 Not Used	64	Always set to 0.
7 Power On	128	Power has been turned off and on since the last time the event register was read or cleared.

The Standard Event register is cleared when:

- You execute the `*CLS` (clear status) command.
- You query the event register using the `*ESR?` (event status register) command.

The Standard Event enable register is cleared when:

- You execute the `*ESE 0` command.
- You turn on the power and have previously configured the function generator using the `*PSC 1` command.
- The enable register *will not* be cleared at power-on if you have previously configured the function generator using `*PSC 0`.

Status Reporting Commands

SYSTem:ERRor?
Read one error from the *error queue.* When the front-panel **ERROR** annunciator turns on, one or more command syntax or hardware errors have been detected. A record of up to 20 errors can be stored in the function generator's error queue. *See chapter 5, "Error Messages," for a complete listing of the errors.*

- Errors are retrieved in first-in-first-out (FIFO) order. The first error returned is the first error that was stored. When you have read all errors from the queue, the **ERROR** annunciator turns off. The function generator beeps once each time an error is generated.
- If more than 20 errors have occurred, the last error stored in the queue (the most recent error) is replaced with *-350, "Too many errors"*. No additional errors are stored until you remove errors from the queue. If no errors have occurred when you read the error queue, the function generator responds with *+0, "No error"*.
- The error queue is cleared when power has been off or after a `*CLS` (clear status) command has been executed. The `*RST` (reset) command *does not* clear the error queue.

***CLS**
Clear the Status Byte summary register and all event registers.

***ESE** <*enable value*>
Enable bits in the Standard Event enable register. The selected bits are then reported to the Status Byte.

***ESE?**
Query the Standard Event enable register. The function generator returns a decimal value which corresponds to the binary-weighted sum of all bits set in the register.

***ESR?**
Query the Standard event register. The function generator returns a decimal value which corresponds to the binary-weighted sum of all bits set in the register.

***OPC**
Set the "operation complete" bit (bit 0) in the Standard Event register after the previous commands have been executed. *Used only in the triggered burst mode and triggered sweep mode.*

***OPC?**
Return "1" to the output buffer after the previous commands have been executed. *Used only in the triggered burst mode and triggered sweep mode.*

***PSC {0|1}**
Power-on status clear. Clear the Status Byte and Standard Event register enable masks when power is turned on (`*PSC 1`). When `*PSC 0` is in effect, the Status Byte and Standard Event register enable masks *are not* cleared when power is turned on. *The factory setting is "1" (enabled).* [*Stored in non-volatile memory*]

***PSC?**
Query the power-on status clear setting. Returns "0" (`*PSC 0`) or "1" (`*PSC 1`).

SRE <enable value***>**
Enable bits in the Status Byte enable register.

***SRE?**
Query the Status Byte enable register. The function generator returns a decimal value which corresponds to the binary-weighted sum of all bits set in the register.

***STB?**
Query the Status Byte summary register. The `*STB?` command is similar to a serial poll but it is processed like any other instrument command. The `*STB?` command returns the same result as a serial poll but the "request service" bit (bit 6) *is not* cleared if a serial poll has occurred.

***WAI**
Wait for all pending operations to complete before executing any additional commands over the interface. *Used only in the triggered burst mode and triggered sweep mode.*

An Introduction to the SCPI Language

SCPI (*Standard Commands for Programmable Instruments*) is an ASCII-based instrument command language designed for test and measurement instruments. *Refer to "Simplified Programming Overview," starting on page 136, for an introduction to the basic techniques used to program the function generator over the remote interface.*

SCPI commands are based on a hierarchical structure, also known as a *tree system*. In this system, associated commands are grouped together under a common node or root, thus forming *subsystems*. A portion of the SOURCE subsystem is shown below to illustrate the tree system.

```
SOURce:
     FREQuency:
          STARt {<frequency>|MINimum|MAXimum}
     FREQuency:
          STARt? [MINimum|MAXimum]
     FREQuency:
          STOP {<frequency>|MINimum|MAXimum}
     FREQuency:
          STOP? [MINimum|MAXimum]

     SWEep:
          SPACing {LINear|LOGarithmic}
     SWEep:
          SPACing?
     SWEep:
          TIME {<seconds>|MINimum|MAXimum}
     SWEep:
          TIME? [MINimum|MAXimum]
     SWEep:
          STATe {OFF|ON}
     SWEep:
          STATe?
```

SOURce is the root keyword of the command, FREQuency and SWEep are second-level keywords, and STARt and STOP are third-level keywords. A *colon* (**:**) separates a command keyword from a lower-level keyword.

Command Format Used in This Manual

The format used to show commands in this manual is shown below:

```
FREQuency {<frequency>|MINimum|MAXimum}
```

The command syntax shows most commands (and some parameters) as a mixture of upper- and lower-case letters. The upper-case letters indicate the abbreviated spelling for the command. For shorter program lines, send the abbreviated form. For better program readability, send the long form.

For example, in the above syntax statement, `FREQ` and `FREQUENCY` are both acceptable forms. You can use upper- or lower-case letters. Therefore, `FREQUENCY`, `freq`, and `Freq` are all acceptable. Other forms, such as `FRE` and `FREQUEN`, will generate an error.

Braces (**{ }**) enclose the parameter choices for a given command string. The braces are not sent with the command string.

A *vertical bar* (**|**) separates multiple parameter choices for a given command string.

Triangle brackets (**< >**) indicate that you must specify a value for the enclosed parameter. For example, the above syntax statement shows the *frequency* parameter enclosed in triangle brackets. The brackets are not sent with the command string. You must specify a value for the parameter (such as `"FREQ 5000"`).

Some parameters are enclosed in *square brackets* (**[ ]**). The brackets indicate that the parameter is optional and can be omitted. The brackets are not sent with the command string. If you do not specify a value for an optional parameter, the function generator chooses a default value.

Command Separators

A *colon* (**:**) is used to separate a command keyword from a lower-level keyword. You must insert a *blank space* to separate a parameter from a command keyword. If a command requires more than one parameter, you must separate adjacent parameters using a *comma* as shown below:

```
"APPL:SIN  5 KHZ, 3.0 VPP, -2.5 V"
```

A *semicolon* (**;**) is used to separate commands within the *same* subsystem, and can also minimize typing. For example, sending the following command string:

```
"FREQ:START 10; STOP 1000; MODE SWEEP"
```

... is the same as sending the following three commands:

```
"FREQ:START 10"
"FREQ:STOP 1000"
"FREQ:MODE SWEEP"
```

Use a colon *and* a semicolon to link commands from *different* subsystems. For example, in the following command string, an error is generated if you do not use both the colon *and* semicolon:

```
"SWE:STAT ON;:TRIG:SOUR EXT"
```

Using the *MIN* and *MAX* Parameters

You can substitute `MINimum` or `MAXimum` in place of a parameter for many commands. For example, consider the following command:

```
FREQuency {<frequency>|MINimum|MAXimum}
```

Instead of selecting a specific frequency, you can substitute `MIN` to set the frequency to its minimum value or `MAX` to set the frequency to its maximum value.

Querying Parameter Settings

You can query the current value of most parameters by adding a *question mark* (**?**) to the command. For example, the following command sets the output frequency to 5 kHz:

```
"FREQ 5000"
```

You can query the frequency value by executing:

```
"FREQ?"
```

You can also query the minimum or maximum frequency allowed with the present function as follows:

```
"FREQ? MIN"
"FREQ? MAX"
```

SCPI Command Terminators

A command string sent to the function generator *must* terminate with a <*new line*> character. The IEEE-488 *EOI* (end-or-identify) message is interpreted as a <*new line*> character and can be used to terminate a command string in place of a <*new line*> character. A <*carriage return*> followed by a <*new line*> is also accepted. Command string termination will *always* reset the current SCPI command path to the root level.

IEEE-488.2 Common Commands

The IEEE-488.2 standard defines a set of *common commands* that perform functions like reset, self-test, and status operations. Common commands always begin with an asterisk (*), are four to five characters in length, and may include one or more parameters. The command keyword is separated from the first parameter by a *blank space*. Use a *semicolon* (**;**) to separate multiple commands as shown below:

```
"*RST; *CLS; *ESE 32; *OPC?"
```

SCPI Parameter Types

The SCPI language defines several different data formats to be used in program messages and response messages.

Numeric Parameters Commands that require numeric parameters will accept all commonly used decimal representations of numbers including optional signs, decimal points, and scientific notation. Special values for numeric parameters like `MINimum`, `MAXimum`, and `DEFault` are also accepted. You can also send engineering unit suffixes with numeric parameters (e.g., `Mhz` or `Khz`). If only specific numeric values are accepted, the function generator will automatically round the input numeric parameters. The following command uses a numeric parameter:

```
FREQuency {<frequency>|MINimum|MAXimum}
```

Discrete Parameters Discrete parameters are used to program settings that have a limited number of values (like `BUS`, `IMMediate`, `EXTernal`). They have a short form and a long form just like command keywords. You can mix upper- and lower-case letters. Query responses will *always* return the short form in all upper-case letters. The following command uses discrete parameters:

```
SWEep:SPACing {LINear|LOGarithmic}
```

Boolean Parameters Boolean parameters represent a single binary condition that is either true or false. For a false condition, the function generator will accept “OFF” or “0”. For a true condition, the function generator will accept “ON” or “1”. When you query a boolean setting, the instrument will *always* return “0” or “1”. The following command uses a boolean parameter:

```
AM:STATe {OFF|ON}
```

String Parameters String parameters can contain virtually any set of ASCII characters. A string *must* begin and end with matching quotes; either with a single quote or with a double quote. You can include the quote delimiter as part of the string by typing it twice without any characters in between. The following command uses a string parameter:

```
DISPlay:TEXT <quoted string>
```

Halting an Output in Progress

You can send a *device clear* at any time to stop an output in progress over the GPIB interface. The status registers, the error queue, and all configuration states are left unchanged when a device clear message is received. Device clear performs the following actions:

- The function generator's input and output buffers are cleared.
- The function generator is prepared to accept a new command string.
- The following statement shows how to send a device clear over the GPIB interface:

```
CLEAR 710        IEEE-488 Device Clear
```

- The following statement shows how to send a device clear over the GPIB interface using the GPIB Command Library for *C* or *QuickBASIC*:

```
IOCLEAR (710)
```

For RS-232 operation, sending the <Ctrl-C> character will perform the same operation as the IEEE-488 device clear message. The function generator's DTR (data terminal ready) handshake line is set "true" following a device clear message. See "DTR/DSR Handshake Protocol," on page 198 for further details.

To set the GPIB address

Each device on the GPIB (IEEE-488) interface must have a unique address. You can set the function generator's address to any value between 0 and 30. *The address is set to **10** when the function generator is shipped from the factory*. The current address is displayed momentarily on the front panel when you turn on the function generator. *See also "GPIB Address," on page 114.*

Shift
Menu On/Off

1 Turn on the menu.

```
A: MOD MENU
```

< <

2 Move across to the I/O MENU choice on this level.

```
E: I/O MENU
```

∨

3 Move down a level to the HPIB ADDR command.

```
1: HPIB ADDR
```

∨

4 Move down to the "PARAMETER" level to set the address.

Use the left/right and down/up arrow keys to change the address.

```
∧10      ADDR
```

Enter

5 Save the change and turn off the menu.

The address is stored in *non-volatile* memory, and *does not* change when power has been off or after a remote interface reset.

To select the remote interface

The function generator is shipped with both an GPIB (IEEE-488) interface and an RS-232 interface. Only one interface can be enabled at a time. *The **GPIB interface** is selected when the function generator is shipped from the factory*. *See also "Remote Interface Selection," on page 115.*

Shift
Menu On/Off

1 Turn on the menu.

```
A: MOD MENU
```

< <

2 Move across to the I/O MENU choice on this level.

```
E: I/O MENU
```

v >

3 Move down a level and then across to the INTERFACE choice.

```
2: INTERFACE
```

v

4 Move down to the "PARAMETER" level to select the interface.

Use the left/right arrow keys to see the interface choices. Choose from the following: HPIB / 488 or RS-232.

```
HPIB / 488
```

Enter

5 Save the change and turn off the menu.

The interface selection is stored in *non-volatile* memory, and *does not* change when power has been off or after a remote interface reset.

To set the baud rate

You can select one of six baud rates for RS-232 operation. *The rate is set to **9600 baud** when the function generator is shipped from the factory. See also "Baud Rate Selection," on page 116.*

Shift
Menu On/Off

1 Turn on the menu.

```
A: MOD MENU
```

< <

2 Move across to the I/O MENU choice on this level.

```
E: I/O MENU
```

∨ > >

3 Move down a level and then across to the BAUD RATE choice.

```
3: BAUD RATE
```

∨

4 Move down to the "PARAMETER" level to select the baud rate.

Use the left/right arrow keys to see the baud rate choices. Choose from one of the following: 300, 600, 1200, 2400, 4800, or **9600** baud.

```
9600  BAUD
```

Enter

5 Save the change and exit the menu.

The baud rate selection is stored in *non-volatile* memory, and *does not* change when power has been off or after a remote interface reset.

To set the parity

You can select the parity for RS-232 operation. *The function generator is configured for **8 data bits with no parity** when shipped from the factory. See also "Parity Selection," on page 116.*

Shift
Menu On/Off

1 Turn on the menu.

```
A: MOD MENU
```

< <

2 Move across to the I/O MENU choice on this level.

```
E: I/O MENU
```

∨ < <

3 Move down a level and then across to the PARITY choice.

```
4: PARITY
```

∨

4 Move down to the "PARAMETER" level to select the parity.

Use the left/right arrow keys to see the parity choices. Choose from one of the following: **None: 8 Bits**, Odd: 7 Bits, or Even: 7 bits. When you set parity, you are indirectly setting the number of data bits.

```
NONE: 8 BITS
```

Enter

5 Save the change and turn off the menu.

The parity selection is stored in *non-volatile* memory, and *does not* change when power has been off or after a remote interface reset.

SCPI Conformance Information

The Agilent 33120A Function Generator/Arbitrary Waveform Generator conforms to the 1993.0 version of the SCPI standard. Many of the commands required by the standard are accepted by the function generator but are not described in this manual for simplicity or clarity. Most of these non-documented commands duplicate the functionality of a command already described in this manual.

SCPI Confirmed Commands The following table lists the SCPI-approved commands that are used by the function generator.

SCPI Confirmed Commands

```
CALibration
  [:ALL]?
  :VALue <value>
  :VALue?

DATA
  :CATalog?
  :COPY <destination arb name> [,VOLATILE]
  [:DATA] VOLATILE, <value>,<value>, . . .
  :DELete:ALL
  :DELete[:NAME] <arb name>

DISPlay
  [WINDow][:STATe] {OFF|ON}
  [WINDow][:STATe]?
  [WINDow]:TEXT:CLEar
  [WINDow]:TEXT[:DATA] <quoted string>
  [WINDow]:TEXT[:DATA]?

FORMat
  :BORDer {NORMal|SWAPped}
  :BORDer?

[SOURce]
  :AM:DEPTh {<depth in percent>|MINimum|MAXimum}
  :AM:DEPTh? [MINimum|MAXimum]
  :AM:INTernal:FREQuency {<frequency>|MINimum|MAXimum}
  :AM:INTernal:FREQuency? [MINimum|MAXimum]
  :AM:SOURce EXTernal
  :AM:SOURce?
```

SCPI Confirmed Commands *(continued)*

```
[SOURce]
  :AM:STATe {OFF|ON}
  :AM:STATe?
  :FM:DEViation {<peak deviation in Hz>|MINimum|MAXimum}
  :FM:DEViation? [MINimum|MAXimum]
  :FM:INTernal:FREQuency {<frequency>|MINimum|MAXimum}
  :FM:INTernal:FREQuency? [MINimum|MAXimum]
  :FM:STATe {OFF|ON}
  :FM:STATe?
  :FREQuency {<frequency>|MINimum|MAXimum}
  :FREQuency? [MINimum|MAXimum]
  :FREQuency:CENTer
  :FREQuency:MODE
  :FREQuency:SPAN
  :FREQuency:STARt {<frequency>|MINimum|MAXimum}
  :FREQuency:STARt? [MINimum|MAXimum]
  :FREQuency:STOP {<frequency>|MINimum|MAXimum}
  :FREQuency:STOP? [MINimum|MAXimum]
  :FUNCtion:SHAPe {SINusoid|SQUare|TRIangle|RAMP|NOISe|DC|USER}
  :FUNCtion:SHAPe?
  :PULSe:DCYCle {<percent>|MINimum|MAXimum}
  :PULSe:DCYCle? [MINimum|MAXimum]
  :SWEep:SPACing {LINear|LOGarithmic}
  :SWEep:SPACing?
  :SWEep:TIME {<seconds>|MINimum|MAXimum}
  :SWEep:TIME? [MINimum|MAXimum]
  :VOLTage[:LEVel][:IMMediate]...
      [:AMPLitude] {<amplitude>|MINimum|MAXimum}
  :VOLTage[:LEVel][:IMMediate][:AMPLitude]? [MINimum|MAXimum]
  :VOLTage[:LEVel][:IMMediate]:OFFSet {<offset>|MINimum|MAXimum}
  :VOLTage[:LEVel][:IMMediate]:OFFSet? [MINimum|MAXimum]
  :VOLTage:UNIT {VPP|VRMS|DBM|DEFault}
  :VOLTage:UNIT?

SYSTem
  :BEEPer[IMMediate]
  :ERRor?
  :VERSion?

TRIGger
  [SEQuence]:SOURce {IMMediate|EXTernal|BUS}
  [SEQuence]:SOURce?
```

Device-Specific Commands The following commands are designed specifically for the 33120A. They are not included in the 1993.0 version of the SCPI standard. However, these commands are designed with the SCPI standard in mind and they follow all of the command syntax rules defined by the standard.

Non-SCPI Commands

```
CALibration
  :COUNt?
  :SECure:CODE <new code>
  :SECure:STATe {OFF|ON},<code>
  :SECure:STATe?
  :SETup <0|1|2|3| ... |84>
  :SETup?
  :STRing <quoted string>
  :STRing?

DATA
  :ATTRibute:AVERage? <arb name>
  :ATTRibute:CFACtor? <arb name>
  :ATTRibute:POINts? <arb name>
  :ATTRibute:PTPeak? <arb name>
  :DAC VOLATILE, {<binary block>|<value>,<value>, . . .}
  :NVOLatile:CATalog?
  :NVOLatile:FREE?

OUTPut
  :LOAD {50|INFinity|MINimum|MAXimum}
  :LOAD? [MINimum|MAXimum]
  :SYNC {OFF|ON}
  :SYNC?

MEMory:STATe:DELete {0|1|2|3}

[SOURce]
  :AM:INTernal:FUNCtion {SINusoid|SQUare|TRIangle|RAMP|NOISe|USER}
  :AM:INTernal:FUNCtion?
  :APPLy:SINusoid [<frequency> [,<amplitude> [,<offset>] ]]
  :APPLy:SQUare [<frequency> [,<amplitude> [,<offset>] ]]
  :APPLy:TRIangle [<frequency> [,<amplitude> [,<offset>] ]]
  :APPLy:RAMP [<frequency> [,<amplitude> [,<offset>] ]]
  :APPLy:NOISe [<frequency|DEFault> [,<amplitude> [,<offset>] ]]
  :APPLy:DC [<frequency|DEFault> [,<amplitude|DEFault> [,<offset>] ]]
  :APPLy:USER [<frequency> [,<amplitude> [,<offset>] ]]
  :APPLy?
```

Non-SCPI Commands *(continued)*

```
[SOURce]
  :BM:INTernal:RATE {<frequency>|MINimum|MAXimum}
  :BM:INTernal:RATE? [MINimum|MAXimum]
  :BM:NCYCles {<# cycles>|INFinity|MINimum|MAXimum}
  :BM:NCYCles? [MINimum|MAXimum]
  :BM:PHASe {<degrees>|MINimum|MAXimum}
  :BM:PHASe? [MINimum|MAXimum]
  :BM:SOURce {INTernal|EXTernal}
  :BM:SOURce?
  :BM:STATe {OFF|ON}
  :BM:STATe?
  :FM:INTernal:FUNCtion {SINusoid|SQUare|TRIangle|RAMP|NOISe|USER}
  :FM:INTernal:FUNCtion?
  :FSKey:FREQuency {<frequency>|MINimum|MAXimum}
  :FSKey:FREQuency? [MINimum|MAXimum]
  :FSKey:INTernal:RATE {<rate in Hz>|MINimum|MAXimum}
  :FSKey:INTernal:RATE? [MINimum|MAXimum]
  :FSKey:SOURce {INTernal|EXTernal}
  :FSKey:SOURce?
  :FSKey:STATe {OFF|ON}
  :FSKey:STATe?
  :FUNCtion:USER {<arb name>|VOLATILE}
  :FUNCtion:USER?
  :SWEep:STATe {OFF|ON}
  :SWEep:STATe?

SYSTem:
  :LOCal
  :REMote
  :RWLock
```

IEEE-488 Conformance Information

Dedicated Hardware Lines

ATN	*Attention*
IFC	*Interface Clear*
REN	*Remote Enable*
SRQ	*Service Request Enable*

Addressed Commands

DCL	*Device Clear*
EOI	*End or Identify Terminator*
GET	*Group Execute Trigger*
GTL	*Go To Local*
LLO	*Local Lockout*
SDC	*Selected Device Clear*
SPD	*Serial Poll Disable*
SPE	*Serial Poll Enable*

Capability Identification Codes

```
SH1, AH1, T6, L4, SR1, RL1,
PP0, DC1, DT1, C0, E2
```

IEEE-488.2 Common Commands

```
*CLS
*ESE <enable value>
*ESE?
*ESR?
*IDN?
*OPC
*OPC?
*PSC {0|1}
*PSC?
*RST
*SAV {0|1|2|3}
*RCL {0|1|2|3}
*SRE <enable value>
*SRE?
*STB?
*TRG
*TST?
*WAI
```